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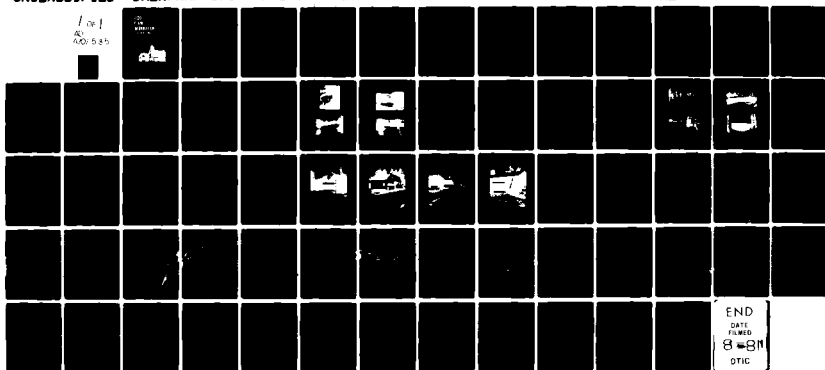
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FLOOD PLAIN INFORMATION

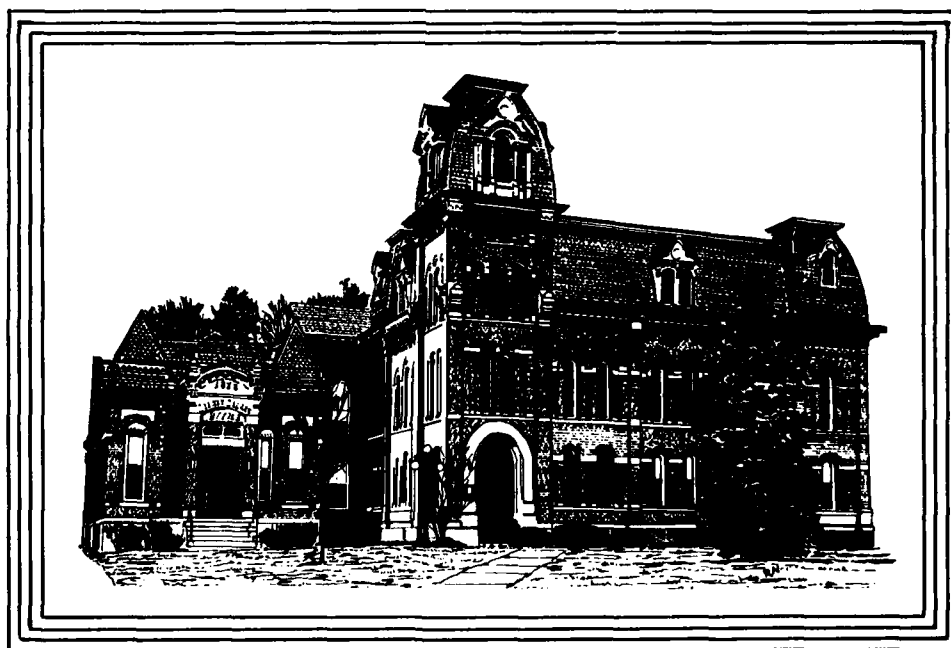
DELHI, NEW YORK

WEST BRANCH DELAWARE RIVER AND
LITTLE DELAWARE RIVER

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WATER RESOURCES PLANNING BOARD BY U.S. ARMY CORPS OF
ENGINEERS, PHILADELPHIA DISTRICT

JUNE 1974

REPT. NO: DAEN/NAP-82040/FPI-19-74/06

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TO THE REQUESTOR:

This Flood Plain Information (FPI) Report was prepared by the Philadelphia District office of the U.S. Army Corps of Engineers, under the continuing authority of the 1960 Flood Control Act, as amended. The report contains valuable background information, discussion of flood characteristics and historical flood data for the study area. The report also presents through tables, profiles, maps and text, the results of engineering studies to determine the possible magnitude and extent of future floods, because knowledge of flood potential and flood hazards is important in land use planning and for management decisions concerning floodplain utilization. These projections of possible flood events and their frequency of occurrence were based on conditions in the study area at the time the report was prepared.

Since the publication of this FPI Report, other engineering studies or reports may have been published for the area. Among these are Flood Insurance Studies prepared by the Federal Insurance Administration of the Federal Emergency Management Agency, Flood Insurance Studies generally provide different types of flood hazard data (including information pertinent to setting flood insurance rates) and different types of floodplain mapping for regulatory purposes and in some cases provide updated technical data based on recent flood events or changes in the study area that may have occurred since the publication of this report.

It is strongly suggested that, where available, Flood Insurance Studies and other sources of flood hazard data be sought out for the additional, and, in some cases, updated flood plain information which they might provide. Should you have any questions concerning the preparation of, or data contained in this FPI Report, please contact:

U.S. Army Corps of Engineers
Philadelphia District
Custom House, 2nd and Chestnut Streets
Philadelphia, PA 19106

ATTN: Flood Plain Mgt. Services Branch, NAPEN-M

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report covered the flood situation along the West Branch Delaware River from Fitches Bridge in East Delhi, NY. downstream to a point 200 feet past its confluence with Peaks Brook and also covered the Little Delaware River from its mouth upstream to the New York State Route 28 Bridge near Lake Delaware. It included a history of flooding in the Town and Village of Delhi and identified those areas subject to possible future floods. Maps, photographs, profiles and cross sections of this flood plain are found within the report.		

Under authority of Section 206 of the 1960 Flood Control Act as amended the flood plain information was prepared by the U.S. Army Corps of Engineers Philadelphia District at the request of the Upper Delaware River Regional Water Resources Planning Board. The information should be considered for its historical nature. Since the publication of the FPI report other Flood Insurance studies have been undertaken and should also be consulted for more current information.

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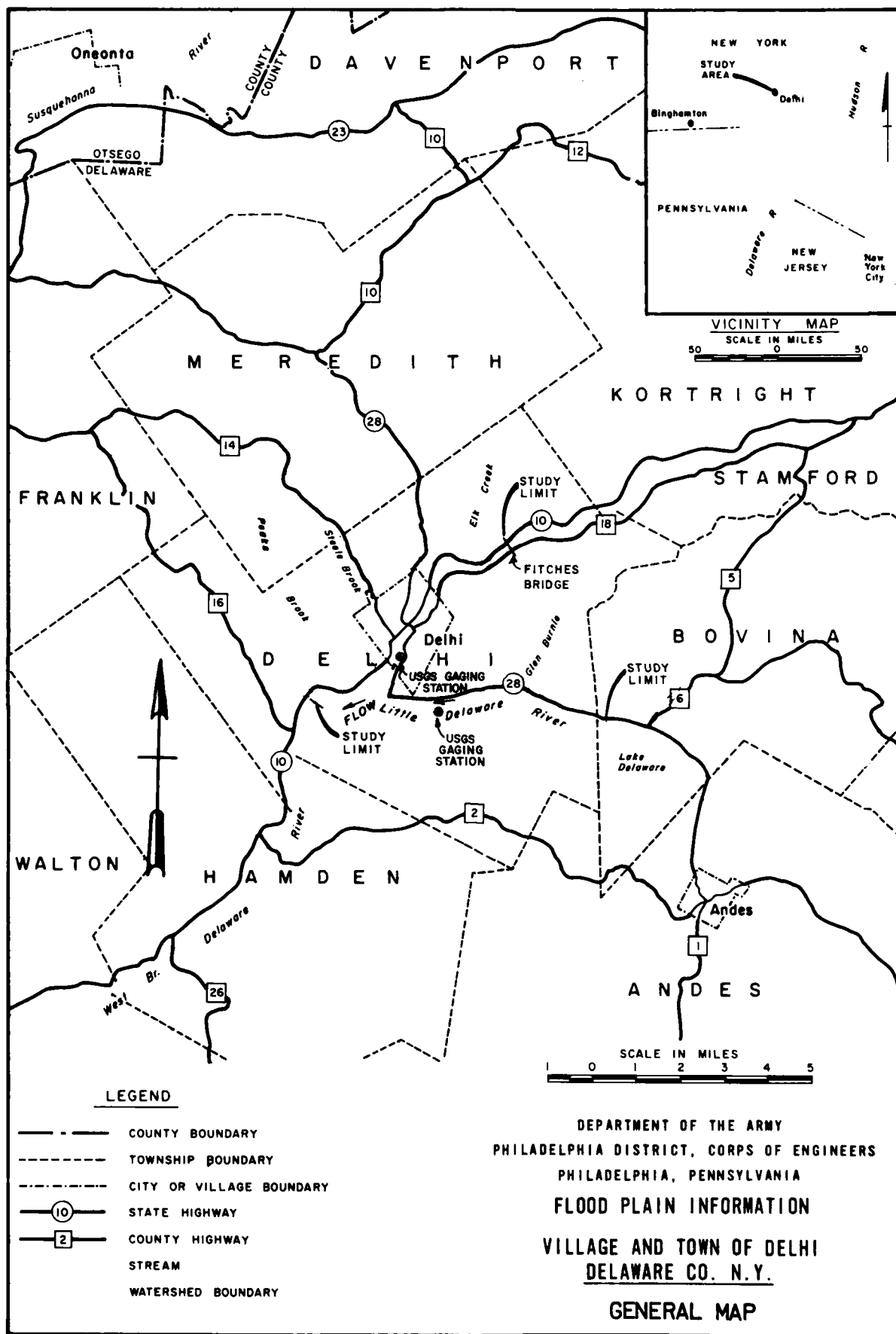
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PREFACE

This report covers the flood situation along West Branch Delaware River from Fitches Bridge in East Delhi, New York, downstream to a point 200 feet past its confluence with Peaks Brook and also covers the Little Delaware River from its mouth upstream to the New York State Route 28 Bridge near Lake Delaware. The properties on the flood plains along these streams are primarily residential and commercial in nature and have been damaged by the floods of July 7-8, 1935; September 21, 1938; June 29, 1973; and, December 20-21, 1973. The open spaces in the flood plains which may come under pressure for future development are limited. Although large floods have occurred in the past, studies indicate that even larger floods are possible.

This report has been prepared because a knowledge of flood potential and flood hazards is important in land use planning and for management decisions concerning flood plain utilization. It includes a history of flooding in the Town and Village of Delhi and identifies those areas that are subject to possible future floods. Special emphasis is given to these floods through maps, photographs, profiles, and cross sections. The report does not provide solutions to flood problems; however, it does furnish a suitable basis for the adoption of land use controls to guide flood plain development and thereby prevent intensification of the loss problems. It will also aid in the identification of areas where other flood damage reduction techniques such as works to modify flooding and adjustments including flood proofing might be embodied in an overall Flood Plain Management (FPM) program. Other FPM program studies—those of environmental attributes and the current and future land use role of the flood plain as part of its surroundings—would also profit from this information.

At the request of the Upper Delaware River Regional Water Resources Planning Board and indorsement of the New York State Department of Environmental Conservation, this report was prepared by the Philadelphia District Office of the Corps of Engineers, Department of the Army, under continuing authority provided in Section 206 of the 1960 Flood Control Act, as amended.

Assistance and cooperation of the United States Geological Survey (U.S.G.S.), "The Delaware Republican Express," the Delaware County Highway Department, the Town of Delhi Highway Department, and private citizens in supplying useful data are appreciated. Flood photographs in this report were supplied through the courtesy of Mr. Greg Fieg of the "Republican Express." Other photographs by Mr. Ernest Swenson, Corps of Engineers.

Additional copies of this report can be obtained from the Upper Delaware River Regional Water Resources Planning Board. The Philadelphia District Office, upon request, will provide technical assistance to planning agencies in the interpretation and use of the data presented as well as planning guidance and further assistance, including the development of additional technical information.

BACKGROUND INFORMATION

Settlement

The Delaware River and its many tributaries attracted early settlers to the Delaware County, New York, area. A party of 11 Dutchmen from Hurley, Ulster County, negotiated with Chancellor Livingston to buy land in what is now Middletown for 20 shillings an acre. They moved their families there in 1763 and soon others followed. The abominable alliances between Joseph Brant's Mohawks and the Tories during the American Revolution all but decimated the area. However, after the war new settlers flocked in and by 1794 the residents, then belonging to Ulster and Otsego Counties, began agitating for separation. In 1797, the State Legislature designated the area as Delaware County.

The statute creating the county provided that a court house and jail be erected within two miles of the Little Delaware River's mouth, which was approximately in the center of the County. In 1798, the site of the court house, and by the same token, the site of the Village of Delhi were fixed. Delhi's early settlers migrated from the mountainous regions of New England. They found the moderate slopes provided better conditions for farming.

Political and commercial activity in the Village coupled with agriculture and dairying in the Town were the mainstay of the population. Retailers in the Village served neighboring farms as a center for dry goods and staples that could not be obtained on self-sufficient farms. Rail transportation and improved highways made it possible to transport farm products to cities along the east coast. As the farms became more specialized, commercial activity in the Village improved. Law offices, a bank and retailers clustered around the complex of County offices in the Village as is still evident today.

In 1913, The State University Agricultural and Technical College was founded at Delhi. Opened as a school of agricultural and domestic science, its aim was to be responsive to local, regional, and statewide needs. The educational opportunity offered by this two-year college has expanded to include Engineering Technologies, Business Management, and Hotel, Restaurant, and Food Services Divisions. The University has expanded to become the largest single employer in Delhi.

The total population of Delaware County has been decreasing in recent years. However, the Village and Town of Delhi have experienced significant increases in population putting a great deal of pressure on development of the flood plain.

The Stream and Its Valley

West Branch Delaware River, with a total drainage area of 664 square miles, has its headwaters on the western slopes of the Catskill Mountains in southeastern New York State. It flows in a westerly direction for 85.4 miles to its confluence with East Branch Delaware River at Hancock, New York. Major tributaries within the study area are Elk Creek, Falls Creek, Steele Brook, Peaks Brook, and the Little Delaware River, which is the tributary included in this study. Although the other tributaries have caused damages, they were not included in this study because their stream slopes and general topography would prevent accurate backwater computations. Drainage areas contributing to runoff at locations in the study area are listed in Table 1 and shown on the General Map, Plate 1.

The watershed is characterized by steep hills with narrow rounded tops separated by narrow valleys. In addition to grassland, woodlands, and cultivated fields, a portion of the flood plain within the study area is occupied by the Village of Delhi, New York.

Little Delaware River also has its headwaters on the western slopes of the Catskill Mountains. Flowing in a westerly direction, it joins West Branch Delaware River approximately two miles southeast of the Village of Delhi, New York. The topography is relatively the same as West Branch Delaware River. The stream slope for the 6.5 mile study reach on West Branch Delaware River is 9.0 feet per mile and the 6.0 mile study reach on Little Delaware River slopes 32.1 feet per mile.

The climate is characterized by long, cold winters when temperatures may drop below zero degrees, and warm summers when temperatures reach above 90 degrees with an average annual temperature of 45 degrees. Annual precipitation over the basin averages 42 inches with the major portion occurring during the summer months. Snowfall, which begins as early as September and lasts until May, amounts to approximately 70 inches per year.

Developments in the Flood Plain

Most of the flood plain of West Branch Delaware River is rural and undeveloped. Many areas are utilized for agricultural purposes with other areas remaining as open fields and wooded lots. Delhi and Walton are the only communities of any appreciable size located along West Branch Delaware River. Delhi, the only community within the study area, has some residences, county offices and commercial buildings located on the flood plain. Several small communities, comprised of only a few residential or farm buildings, are also located along the stream. The Cannonsville Reservoir, which provides storage for part of New York City's water supply, is located on the West Branch Delaware River about 34 miles downstream of Delhi.

TABLE 1
DRAINAGE AREAS
West Branch Delaware River and Little Delaware River

Location	Mileage Above Mouth	Drainage Areas	
		Tributary sq mi	Total (a) sq mi
<u>West Branch Delaware River</u>			
Cross section # 1 study limit	56.26	—	205.4
Peaks Brook	56.27	7.8	205.4
Little Delaware River	57.93	52.4	195.8
Steele Brook	59.04	6.9	142.0
Falls Creek	61.42	7.8	132.9
Elk Creek	61.90	15.3	123.7
Fitches Bridge study limit	62.73	—	108.0
<u>Little Delaware River</u>			
Confluence with West Branch Delaware River	0	—	52.4
Tollgate Brook	2.47	1.2	48.2
Hughes Brook	3.34	1.2	46.9
Glen Burnie	4.06	4.0	45.4
Cross Section # 30	6.02	—	37.6
<hr/>			

(a) Includes tributary.

Like that of the West Branch Delaware River, most of the flood plain of Little Delaware River is rural and undeveloped. The stream flows past scattered residences and two small communities consisting of only a few buildings. In addition to residences and agricultural and commercial buildings on the flood plain of West Branch Delaware River and Little Delaware River, associated streets, roads and utilities may also be subject to flooding and subsequent damage.

It is expected that the flood plains of the Delaware River and West Branch Delaware River in the Village and Town of Delhi will come under increasing pressure for development to meet the residential, commercial and industrial needs of an increasing population. See Table 2 for population trends.

TABLE 2
POPULATION TRENDS^(a)
Delaware County, New York

Area	1900	1910	1920	1930	1940	1950	1960	1970
Delaware County	46,413	45,575	42,774	41,163	40,989	44,420	43,540	44,718
Village of Delhi	2,078	1,736	1,669	1,840	1,841	2,223	2,307	3,017
Town of Delhi	1,162	1,079	1,052	1,013	1,109	1,088	1,091	4,617

(a) Source: U.S. Census of Population

FLOOD SITUATION

Sources of Data and Records

The U.S. Geological Survey maintained stream gages on the West Branch Delaware River and Little Delaware River from 1937 until 1970. To supplement the 33 year records at the gaging stations, newspaper files, historical documents and records were searched for information concerning past floods. From these records a knowledge of floods that have occurred on West Branch Delaware River and Little Delaware River was developed.

Maps prepared for this report were based on U.S. Geological Survey Quadrangle Sheets entitled: "Delhi, New York, 1943;" "Andes, New York, 1965;" and "Bloomville, New York, 1943." Stream surveys and structural data on bridges was obtained by field surveys performed by Corps of Engineers, Philadelphia District, personnel.

Flood Season and Flood Characteristics

Major floods have occurred in the study reaches of West Branch Delaware and Little Delaware Rivers during all seasons of the year with the greatest known floods occurring in December 1973, June 1973 and July 1935, and the greatest recorded flood occurring in September 1938. Floodflow stages can rise from normal flow to extreme flood peaks in a relatively short period of time with high velocities in the main channel of the streams.

The precipitation in the June 1973, July 1935, and September 1938 storms consisted entirely of rainfall. Flooding in December 1973 was caused by the combination of torrential rains falling on ground that was covered with about 12 inches of snow, and warm winter temperatures which caused significant snowmelt. In addition to floods caused by runoff from general rainfall, the West Branch Delaware and Little Delaware River Valleys are susceptible to hurricane activity, floods from snowmelt in combination with rainfall, and high backwater caused by ice jams obstructing the channel.

Ice jams may also be a cause of flooding at Delhi. There are no records available indicating the frequency, magnitude or extent of areas flooded by waters blocked by ice jams.

Another major cause of flooding is the result of sheet flow. When tributaries overflow their banks and the topography of the land is such that the flows cannot be redirected back into their channels, sheet flow flooding occurs. Much of the damage during the June 1973 flood resulted when Steele Brook overflowed its banks and caused sheet flow.

Factors Affecting Flooding and Its Impact

Obstructions to floodflows — Natural obstructions to floodflows include trees, brush and other vegetation growing on islands and along the river banks in floodway areas. Rock outcroppings and boulders are another obstruction to floodflows in the study area. Man-made encroachments over the rivers such as bridges can also create more extensive flooding than would otherwise occur. Representative obstructions to floodflows are shown in Figures 1 and 2.

During floods, ice, trees, brush and other vegetation growing in floodways impede floodflows, thus creating backwater and increased flood heights. Trees, boulders, large pieces of ice and other debris may be washed away and carried downstream to collect on bridges and other obstructions to flow. As floodflow increases, masses of debris break loose and a wall of water and debris surges downstream until another obstruction is encountered. Debris may collect against a bridge until the load exceeds its structural capacity and the bridge is destroyed. The limited capacity of obstructive bridges or culverts, debris plugs at the culvert mouth or a combination of these factors retard floodflows and result in flooding upstream, erosion around bridge approach embankments and possible damage to the overlying roadbed.

In general, obstructions restrict floodflows and result in overbank flows and unpredictable areas of flooding, destruction of or damage to bridges and an increased velocity of flow immediately downstream. It is impossible to predict the degree or location of the accumulation of debris; therefore, for the purposes of this report, it was necessary to assume that there would be no accumulation of debris to clog any of the bridge openings in the development of the flood profiles.

West Branch Delaware River and Little Delaware River are spanned 4 and 5 times respectively within the study area by bridges. Pertinent information on all bridges can be found in Table 5 on Page 19. All of these bridges are obstructive to floodflows.

Flood damage reduction measures — There are no existing or authorized flood control projects on the West Branch Delaware River or Little Delaware River within the study area. Village officials are considering applying for federally subsidized flood insurance; however, to qualify, a village zoning ordinance regulating additional construction in the flood plain must be adopted. Although flood insurance will not actually reduce damages, it will give financial aid to victims of flooding. The requirement for the adoption of a flood plain zoning ordinance will help to eliminate increasing damages which are associated with flood plain encroachments.

Other factors and their impacts — The impact of flooding along West Branch Delaware River and Little Delaware River can be affected by the ability of local residents to anticipate and effectively react to a flood emergency. Efficient flood warning and forecasting systems can give homeowners, business, industry and farmers valuable time to remove damageable materials and livestock from low-lying areas. Increased damages to downstream areas

can also be reduced if floatable materials stored in the flood plain can be removed before being carried downstream to block bridges. Implementation of effective flood fighting and emergency evacuation plans can further reduce flood damages and the incidence of personal injury and death once the river has reached flood stage.

Flood warning and forecasting — Inhabitants of the area depend largely on the usual warnings issued through radio, television and local press media. The National Oceanic and Atmospheric Administration (NOAA) maintains year-round surveillance of weather conditions with a station at the Binghamton, New York, airport.

Flood fighting and emergency evacuation plans — There are no formal flood fighting or emergency evacuation plans for the Village or Town of Delhi. When flooding does occur, Delaware County and the Town of Delhi Highway Departments, Delhi Fire Department, local police and citizen volunteers form the nucleus of the flood fighting, rescue and cleanup forces.

Material storage on the flood plain — In the Town of Delhi there is very little floatable material stored on the flood plain. However, in the Village of Delhi, there are storage tanks, containers, lumber, cars and domestic equipment which may be unrestrained and buoyant. During time of floods, these floatable materials may be carried away by floodflows causing serious damage to structures downstream and could clog bridge openings creating more hazardous flooding problems. Figures 3 and 4 show materials that are stored on the flood plain.



FIGURE 1 - Debris gathers on the island upstream of the Kingston Street Bridge increasing the island's effect on obstructing floodflows.



FIGURE 2 - Vegetation along the river banks can become an obstruction to floodflows.



FIGURE 3 - Tanks stored on the island upstream of the Kingston Street Bridge can become floatable and create a hazard downstream.



FIGURE 4 - Miscellaneous floatable material stored on the flood plain can increase flood hazards during time of flooding.

PAST FLOODS

Summary of Historical Floods

Damaging floods have been reported to have occurred in the Delhi, New York, area as early as 1888. Floods causing significant damage are described to have occurred in 1888, 1895, 1897, 1935, 1938, 1942, 1953 and twice in 1973. Among these, the September 1938 flood was the highest of record on the West Branch Delaware River. The floods of July 1935 and December 1973 were reported to have produced higher stages; however, the July 1935 flood took place prior to the installation of the stream gage, and the December 1973 flood took place after removal of the stream gage. Consequently, there is no record of stream flows for these floods. The flood of June 29, 1973, was reported by some residents of the area to be worse than the record flood of July 1935.

Flood Records

Information on historical floods in the Delhi, New York, area was obtained from stream gaging stations maintained by the U.S. Geological Survey at a number of locations within the West Branch Delaware River Watershed at or near Delhi, New York. The stream gages located on the West Branch Delaware River and Little Delaware River were both installed in 1937 and removed in 1970. High water marks of past floods were obtained, residents along the stream were interviewed and newspaper files and historical documents were searched for information concerning past floods. Reported high water marks on West Branch and Little Delaware Rivers are listed in Table 3.

TABLE 3
HIGH WATER MARKS
West Branch Delaware River and Little Delaware River

Location	Date	High Water Mark
		Elevation
		feet - mean sea level datum
<u>West Branch Delaware River</u>		
U.S.G.S. Stream Gage	September 21, 1938	1354.1(a)
	June 29, 1973	1352.1
Delaware County Highway Department	July 7, 1935	1364.2
	December 21, 1973	1361.0
<u>Little Delaware River</u>		
U.S.G.S. Stream Gage	September 21, 1938	1393.7
	June 29, 1973	1393.2
(a) From actual gage reading.		

Flood Descriptions

The following are descriptions of known large floods that have occurred in the vicinity of Delhi, New York:

July 7 and 8, 1935 - The greatest known flood to have occurred at Delhi, New York, was on July 7 and 8, 1935. Severe localized thunderstorms centered along the divide of the Susquehanna and Delaware River Basins caused considerable flooding on several tributaries of the West Branch. Rainfall for the 24 hour period amounted to 8.52 inches at Delhi. The flood inundated 30 acres of land in the commercial and residential sections of the Village of Delhi.

September 21, 1938 - The greatest recorded flood experienced at Delhi occurred on September 21, 1938. A tropical storm whose path was west of the Delaware River Basin unloaded about 4 inches of rain at Delhi.

The following descriptions of known floods that occurred in the Delhi vicinity were provided by Mrs. Henry L. Hovemeyer of THE DELAWARE REPUBLICAN EXPRESS, Delhi, New York:

March 24, 1888 - The freshet — This week the water has been high, instead of a blizzard . . . On Wednesday the flood came . . . the water and ice washed out part of the pier of the short iron bridge at Kingston Street . . . the small bridge at Sherwoods was carried off. Part of Beller's barn sheds and Kipp's outhouse were swept away. The people on Lower Bridge Street and near the mill were driven from the lower stories of their homes.

* * * * *

April 13, 1895 - On Tuesday morning the river was the highest since 1888, and only about 15 inches lower than on that memorable occasion.

* * * * *

August 14, 1897 - Tremendous downpour, thunder, lightning, and flood Tuesday night — Railroad tracks, bridges and roads washed out . . . Houses undermined, and a woman carried away and drowned . . . Mrs. Walter Launt, Hamden, was found in the debris at the head of the flat just above the depot . . . Steele Brook had a rare high and served mud through the Waterworks on Wednesday.

* * * * *

Delaware Republican, July 10, 1935: Flood Waters Cause \$500,000 Damage In Delhi. Great damage to Delhi infiltration plant . . . Stores and dwellings flooded . . . Business places deluged . . . Cellars, gardens washed out . . . Highway and rail service halted . . . Never in history of Delhi and vicinity has been recorded such devastation from rain and flood as visited this county Sunday afternoon and night.

* * * * *

May 28, 1942 - Flash flood results in much damage in vicinity of Delhi . . . Farms, gardens, and bridges victims of heavy rains of Friday night.

* * * * *

August 13, 1953 - A flash flood hit Bovina Center and did extensive damage in that community.

* * * * *

June 29, 1973 - Reported to be the worst natural disaster to hit Delhi; preliminary damage totals reached one million dollars. The flooding was caused by torrential rains and increased when debris gathered at bridges forcing streams out of their banks.

EXCERPTS FROM THE DELAWARE REPUBLICAN EXPRESS (a)
JULY 5, 1973, RELATIVE TO THE FLOOD OF JUNE 29, 1973

Heavy Damage Recorded From Flood In Village Of Delhi

A flood of major proportions has happened again in Delhi. Torrential rains which began in the evening last Thursday and continued without letup through the night were responsible for a repeat performance of the deluge which made a shambles of the lower part of the Village of Delhi on July 6, 1935. "This is worse than the flood of 1935," is the opinion expressed by some who have been in Delhi on both occasions. The fire siren sounding at five o'clock alerted citizens that something was amiss Friday morning. At the lower end of town,

homeowners found torrents of water rushing around foundations of their homes and pouring into their cellars. Delhi firemen called to the scene found need for every piece of equipment in battling the floodwaters which at that early hour had swept uprooted trees and debris against the bridge at Steele Brook on Main Street and formed a dam which sent water raging across lawns and into homes. One had to see to believe the devastation along lower Main Street.

December 27, 1973 - Warming temperatures and torrential rains with about 12 inches of snow on the ground caused widespread flooding in and around Delhi, New York. Photographs of this flooding can be seen in Figures 5, 6 and 7.

(a) Simulated from newspaper clippings.

EXCERPTS FROM THE DELAWARE REPUBLICAN EXPRESS (a)
DECEMBER 27, 1973

Unseasonal Flood Strikes, Village Wants Insurance

Covered Bridge Threatened

Fitches Bridge, one of Delaware County's several antique covered wood structures was also closed although water did not rise above the driving surface of the bridge.

The water rose to the top of the bridge supports striking it with floating debris and large chunks of ice which authorities felt might dislodge the bridge and send it to Delhi.

Motorists who use the bridge regularly then attempted to go around to the next bridge north of Fitches Bridge only to find that closed also as waters streamed over the road at a furious pace.

Page Avenue Closed

Page Avenue in Delhi was closed by the Village as water for a few hours threatened the county

building complex there and water poured into the basements of homes. . . . According to Mayor Volante some residents had to be evacuated.

Sherwoods Closed

The Sherwoods Bridge was also closed as the road leading to it was under water. Motorists used the Andes Road to reach another entrance to the portion of the Back River Road which is served by the Sherwoods Bridge.

Sherwoods later became an island . . . the college golf course, adjacent to the road . . . looked more like a lake than a golf course. At one point, about 30 minutes, the river rose and expanded the golf course lake to include the remaining link on the Back River Road which motorists at that time were taking to DeLancey, the last fordable spot.

(a) Simulated from newspaper clippings.

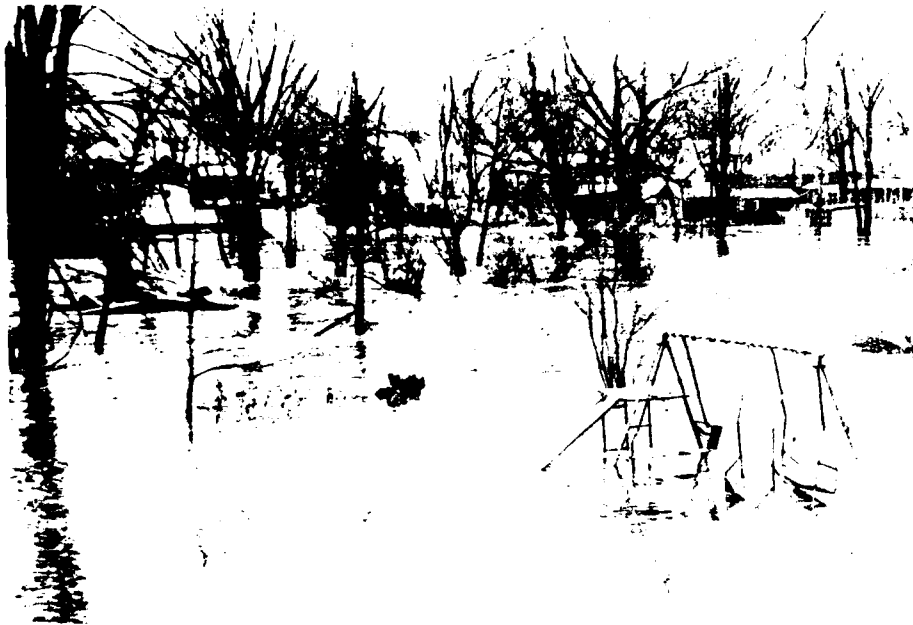


FIGURE 5 - West Branch Delaware River becomes a "lake" at the Village of Delhi during the December 1973 flood.



FIGURE 6 - Page Street closed to allow passage of floodwaters and ice during the flood of December 1973.



FIGURE 7 - Top photograph is Fitches Bridge as it normally appears.
Bottom view is Fitches Bridge during the flood of December 1973.

FUTURE FLOODS

Floods of the same or larger magnitude than those that have occurred in the past could occur in the future. Larger floods have been experienced in the past on streams with similar geographical and physiographical characteristics as those found in the study area. Similar combinations of rainfall and runoff which caused these floods could occur in the Delhi, New York, area. Therefore, to determine the flooding potential of the study area, it was necessary to consider storms and floods that have occurred in regions of like topography, watershed cover and physical characteristics. Discussion of the future floods in this report is limited to those that have been designated as the Intermediate Regional Flood and the Standard Project Flood. The Standard Project Flood represents a reasonable upper limit of expected flooding in the study area. The Intermediate Regional Flood may reasonably be expected to occur more frequently although it will not be as severe as the infrequent Standard Project Flood.

Intermediate Regional Flood

The Intermediate Regional Flood is defined as one that occurs once in 100 years on the average, although it could occur in any year. The peak flow of this flood was developed from statistical analyses of streamflow and precipitation records and runoff characteristics for the stream under study. However, limitations in these records required analyses on a regional rather than a watershed basis. In determining the Intermediate Regional Flood for West Branch Delaware and Little Delaware Rivers, statistical studies were made using the 33 year record of flood data from the U.S. Geological Survey gaging stations throughout the vicinity of Delaware County, New York. Peak flows thus developed for the Intermediate Regional Flood at selected locations in the study area are listed in Table 4.

Standard Project Flood

The Standard Project Flood is defined as a major flood that can be expected to occur from the most severe combination of meteorological and hydrological conditions that is considered reasonably characteristic of the geographical area in which the study area is located, excluding extremely rare combinations. The Corps of Engineers, in cooperation with the NOAA Weather Service, has made comprehensive studies and investigations based on the past records of experienced storms and floods and has developed generalized procedures for estimating the flood potential of streams. Peak discharges for the Standard Project Flood at selected locations in the study area are listed in Table 4. Discharge hydrographs for the Standard Project Flood at stream gaging stations on both the West Branch Delaware River and

Little Delaware River are shown on Plate 12. The relative water surface elevations for the Intermediate Regional Flood and the Standard Project Flood are shown on Plates 8 and 9.

TABLE 4
PEAK FLOWS
Intermediate Regional and Standard Project Floods
West Branch Delaware and Little Delaware Rivers

Location	Mileage Above Mouth	Drainage Area sq mi	Intermediate Regional Flood Discharge cfs	Standard Project Flood Discharge cfs
West Branch Delaware River				
Cross section #1 study limit	56.26	205.4	15,010	60,940
Confluence with Little Delaware River	57.93	195.8	13,420	50,260
Confluence with Steele Brook	59.04	142.0	9,300	32,300
Confluence with Falls Creek	61.42	132.9	8,217	31,420
Confluence with Elk Creek	61.90	123.7	7,313	30,284
Fitches Bridge Study Limit	62.73	108.0	6,340	28,030
Little Delaware River				
Confluence with West Branch Delaware River	0	52.4	5,920	20,570
Confluence with Tollgate Brook	2.47	48.2	4,660	16,240
Confluence with Hughes Brook	3.34	46.9	4,450	15,930
Confluence with Glen Burnie	4.06	45.4	3,830	15,840
Cross section #30	6.02	37.6	2,650	11,670

Frequency

A frequency curve of peak flows was constructed on the basis of available information and computed flows of floods up to the magnitude of the Standard Project Flood. The frequency curve thus derived, which is available on request, reflects the judgment of engineers who have studied the area and are familiar with the region; however, it must be regarded as approximate and should be used with caution in connection with any planning of food plain use. Floods larger than the Standard Project Flood are possible but the combinations of factors necessary to produce such large flows would be extremely rare.

Hazards of Large Floods

The extent of damage caused by any flood depends on the topography of the area flooded, depth and duration of flooding, velocity of flow, rate of rise, and developments in the flood plain. An Intermediate Regional Flood or Standard Project Flood on West Branch Delaware River or Little Delaware River would result in inundation of residential, commercial, light industrial and cultivated farmland sections in the Delhi area. Deep floodwater flowing at high velocity and carrying floating debris would create conditions hazardous to persons and vehicles attempting to cross flooded areas. In general, floodwater three or more feet deep and flowing at a velocity of three or more feet per second could easily sweep an adult person off his feet, thus creating definite danger of injury or drowning. Rapidly rising and swiftly flowing floodwater may trap persons in homes that are ultimately destroyed, or in vehicles that are ultimately submerged or floated. Waterlines can be ruptured by deposits of debris and the force of floodwaters, thus creating the possibility of contaminated domestic water supplies. Damaged sanitary sewer lines and sewage treatment plants could result in the pollution of floodwaters creating health hazards. Isolation of areas by floodwater could create hazards in terms of medical, fire, or law enforcement emergencies.

Flooded areas and flood damages - The areas in the Town and Village of Delhi that would be flooded by the Standard Project Flood are shown on Plate 2, which is also an index map to Plates 3 through 7. Areas that would be flooded by the Intermediate Regional and Standard Project Floods are shown in detail on Plates 3 through 7. The actual limits of these overflow areas may vary somewhat from those shown on the maps because the 100-foot contour interval and scale of the maps do not permit *precise plotting of the flooded area boundaries*. As may be seen from these plates, floodflows from the West Branch Delaware River and its tributary, the Little Delaware River, cover a large portion of the study area. Other tributaries to the West Branch Delaware River can extend the area of flooding when they overflow their banks. Since the topography of the land is such that the flows cannot be redirected back into their channels, the overflow will continue until they join the West Branch Delaware River. This condition results in an undetermined depth of sheet flow. The areas that would be flooded by the Intermediate Regional and Standard Project Floods include commercial, light industrial, residential and farming sections and the associated streets, roads, and private and public utilities in the Village and Town of Delhi. Considerable damage to these facilities would occur during an Intermediate Regional Flood. However, due to the wider extent, greater depths of flooding, higher velocity flow and longer duration of flooding during a Standard Project Flood, damage would be even more severe than during an Intermediate Regional Flood. Plates 8 and 9 show water surface profiles of the Intermediate Regional and Standard Project Floods. Depth of flow in the channel can be estimated from these illustrations. Typical cross sections of the flood plain at selected locations, together with the water surface elevation and lateral extent of the Intermediate Regional and Standard Project Floods are shown on Plates 10 and 11.

Obstructions - During floods, debris collecting on bridges could decrease their carrying capacity and cause greater water depths (backwater effect) upstream of these structures.

Since the occurrence and amount of debris are indeterminate factors, only the physical characteristics of the structures were considered in preparing profiles of the Intermediate Regional and Standard Project Floods. Similarly, the maps of flooded areas show the back-water effect of obstructive bridges and culverts, but do not reflect increased water surface elevation that could be caused by debris collecting against the structures, or by deposition of silt in the stream channel under structures. Of the 9 bridges crossing the streams in the study area, most of them are obstructive to the Intermediate Regional Flood and all are obstructive to the Standard Project Flood. In some cases bridges may be high enough so as not to be inundated by floodflows; however, the approaches to these bridges may be at lower elevations and subject to flooding and rendered impassable. Table 5 lists water surface elevations for all bridges crossing West Branch Delaware and Little Delaware Rivers.

TABLE 5
ELEVATION DATA
Bridges Across West Branch Delaware River and Little Delaware River

Identification	Mileage Above Mouth	Under- clearance Elevation ft-mean sea level datum	Water Surface Elevation	
			Intermediate Regional Flood ft-mean sea level datum	Standard Project Flood
<u>West Branch Delaware River</u>				
Sherwood Road	57.98	1,350.2	1,344.9	1,355.7
Kingston St., N.Y. Rte. 28	59.30	1,362.1	1,359.4	1,366.2
Bridge St.	59.64	1,361.7	1,364.2	1,370.6
Fitches Covered Bridge	62.73	1,383.9	1,382.4	1,391.3
<u>Little Delaware River</u>				
Back River Road	0.15	1,346.4	1,346.9	1,352.1
College Golf Course Footbridge	0.28	1,349.4	1,350.0	1,353.2
College Golf Course Footbridge	0.36	1,353.7	1,353.6	1,356.1
Bridge by USGS Gaging Station	1.79	1,395.9	1,396.9	1,403.6
N.Y. Rte. 28	5.93	1,533.9	1,531.1	1,537.9

Velocities of flow - Water velocities during floods depend largely on the size and shape of the cross sections, conditions of the stream and the bed slope, all of which vary on different streams and at different locations on the same stream. During an Intermediate Regional Flood, velocities of main channel flow for the West Branch Delaware River in the study area would be 5 to 15 feet per second and on the Little Delaware River from 5 to 9 feet per second. Water flowing at this rate is capable of causing severe erosion to streambanks and fill around bridge abutments and transporting large objects. It is expected that velocity

of flow during a Standard Project Flood would be slightly higher than during an Intermediate Regional Flood. Overbank flow in the Delhi area would vary from 1 to 3 feet per second. Water flowing at 2 feet per second or less would deposit debris and silt. Table 6 lists the maximum velocities that would occur in the main channel and overbank areas at selected locations on West Branch Delaware River and Little Delaware River.

TABLE 6
MAXIMUM VELOCITIES
West Branch Delaware River and Little Delaware River

Location	Mileage Above Mouth	Maximum Velocities			
		Intermediate Regional Flood		Standard Project Flood	
		Channel	Overbank ^(b)	Channel	Overbank ^(b)
		ft/sec	ft/sec	ft/sec	ft/sec
<u>West Branch Delaware River</u>					
<u>Cross Section Number^(a)</u>					
1	56.3	13.6	3.1	21.0	5.9
4	57.6	13.1	3.3	17.5	4.7
8	59.0	15.0	3.7	17.5	4.6
16	62.3	5.5	1.1	10.2	2.9
<u>Little Delaware River</u>					
20	0.8	6.0	1.6	13.2	5.0
24	3.1	7.9	2.6	12.0	4.6
28	5.3	9.4	3.1	12.9	4.9
30	6.0	5.7	1.5	6.1	2.4

(a) For cross section location see Plates 3 through 7.

(b) Value given is the greater of the left and right overbank velocity.

Rates of rise and duration of flooding - Intense rainfalls that accompany severe storm fronts usually produce the floods occurring in the Delhi area. There is a time lag of at least several hours to half a day before overbank flooding occurs in the vicinity. Floods generally rise slowly and stay out of banks for long periods of time. For the Standard Project Flood at the U.S.G.S. gaging station locations on West Branch Delaware River and Little Delaware River, Table 7 gives the maximum rate of rise, height of rise (from critical stage level to maximum floodflow level), time of rise (time period corresponding to height of rise), and duration of critical stage (period of time flooding is above critical stage level).

TABLE 7
RATES OF RISE AND DURATION
Standard Project Flood
West Branch Delaware River and Little Delaware River

Location	Mileage Above Mouth	Maximum Rate of Rise <u>ft/hr</u>	Height of Rise <u>ft</u>	Time of Rise <u>hrs</u>	Duration of Critical Stage <u>hrs</u>
West Branch Delaware River at USGS stream gage	59.0	1.6	11.2	32	17
Little Delaware River at USGS stream gage	1.77	1.5	10.0	30	48

Photographs, future flood heights - The levels that the Intermediate Regional and Standard Project Floods are expected to reach at various locations in the Town and Village of Delhi are indicated on the following photographs.



FIGURE 8 - Possible future flood heights near Sherwoods Bridge.



FIGURE 9 - Possible future flood height at the Bowling Alley on Kingston Street.



FIGURE 10 - Past and possible future flood heights at the Delaware County Highway Department.



FIGURE 11 - Possible future flood heights at Fitches Bridge.

GLOSSARY

Backwater. The resulting high water surface in a given stream due to a downstream obstruction or high stages in an intersecting stream.

Flood. An overflow of lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics: The inundation of land is temporary and the land is adjacent to and inundated by overflow from a river, stream, ocean, lake, or other body of standing water.

Normally a "flood" is considered as any temporary rise in streamflow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, rise of ground water coincident with increased streamflow, and other problems.

Flood Crest. The maximum stage or elevation reached by the waters of a flood at a given location.

Flood Plain. The areas adjoining a river, stream, watercourse, ocean, lake, or other body of standing water that have been or may be covered by floodwater.

Flood Profile. A graph showing the relationship of water surface elevation to location, the latter generally expressed as distance above mouth for a stream of water flowing in an open channel. It is generally drawn to show surface elevation for the crest of a specific flood, but may be prepared for conditions at a given time or stage.

Flood Stage. The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

Hurricane. An intense cyclonic windstorm of tropical origin in which winds tend to spiral inward in a counterclockwise direction toward a core of low pressure, with maximum surface wind velocities that equal or exceed 75 miles per hour (65 knots) for several minutes or longer at some points. Tropical storm is the term applied if maximum winds are less than 75 miles per hour.

Hydrograph. A graph showing flow values against time at a given point, usually measured in cubic feet per second. The area under the curve indicates total volume of flow.

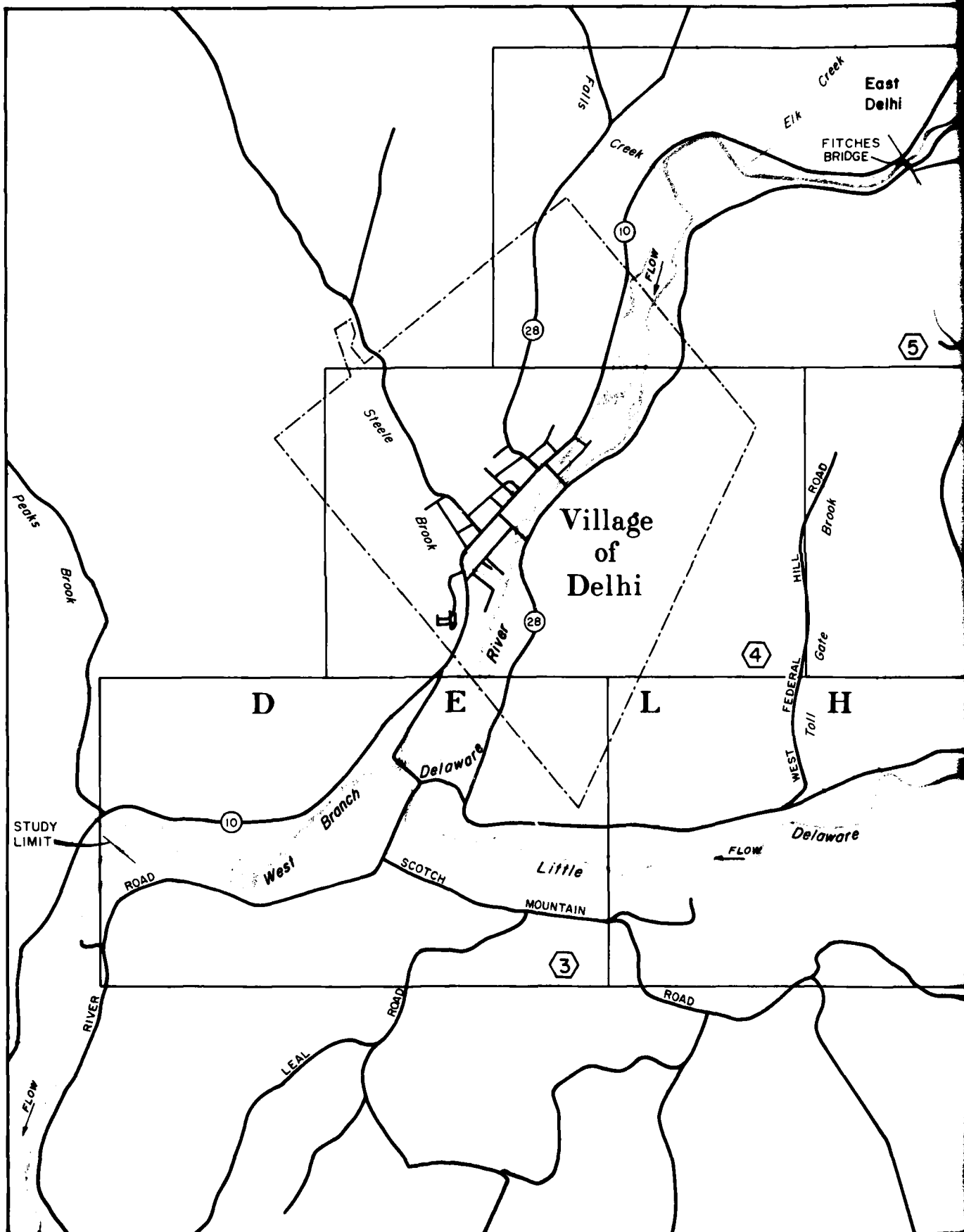
Intermediate Regional Flood. A flood having an average frequency of occurrence in the order of once in 100 years although the flood may occur in any year. It is based on statistical analyses of streamflow records available for the watershed and analyses of rainfall and runoff characteristics in the general region of the watershed.

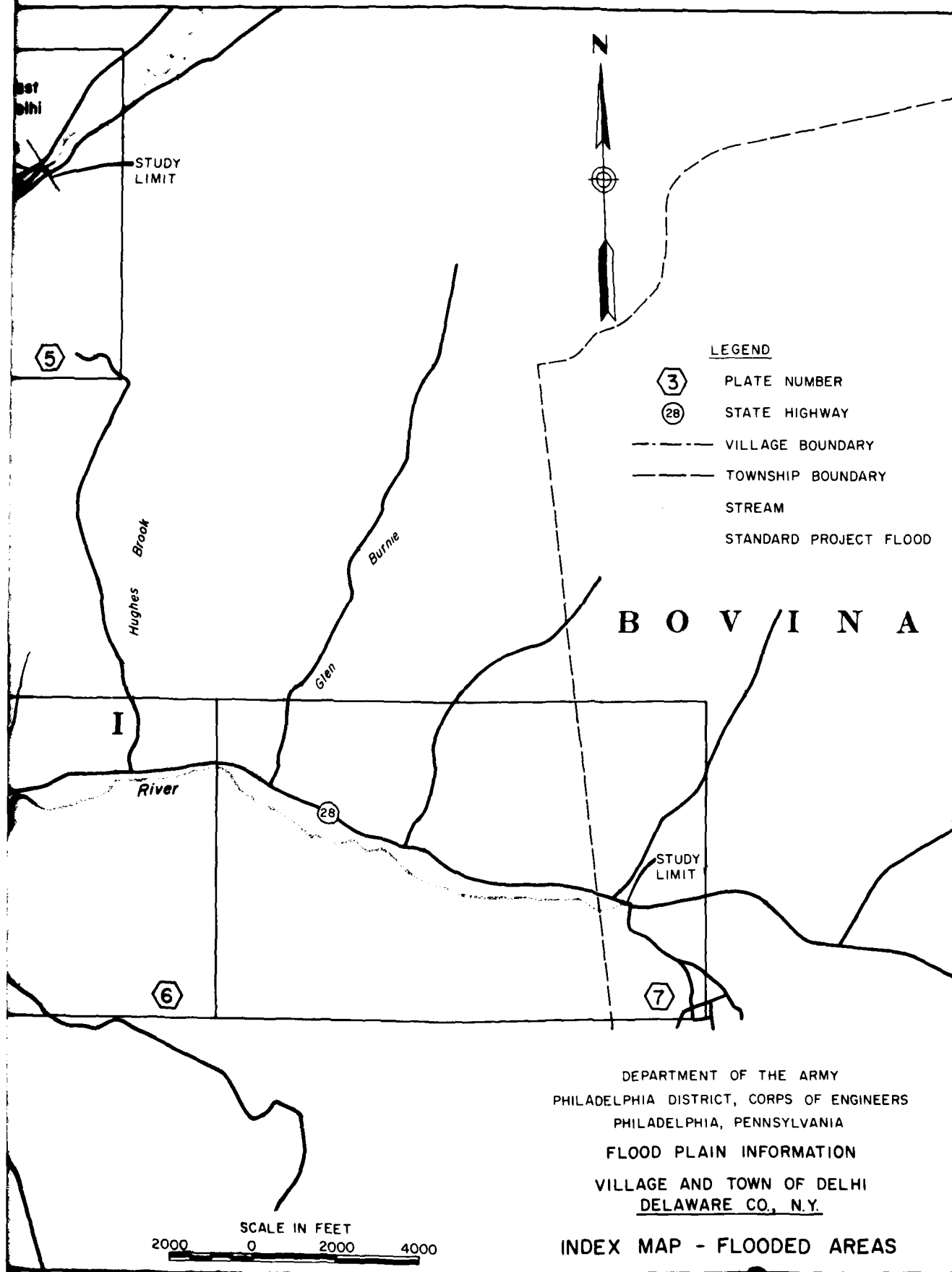
Left Bank. The bank on the left side of a river, stream, or watercourse, looking downstream.

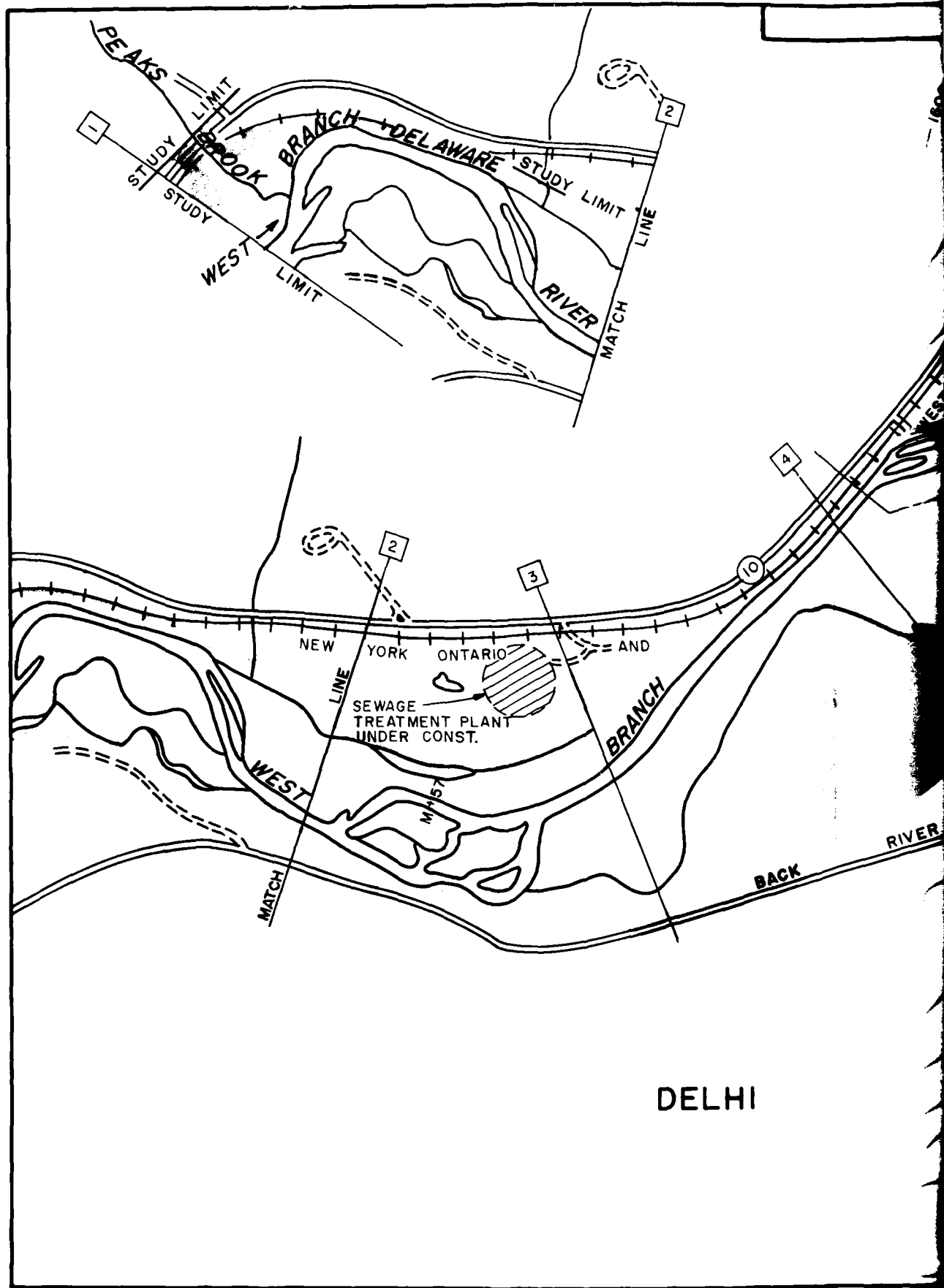
Right Bank. The bank on the right side of a river, stream, or watercourse, looking downstream.

Standard Project Flood. The flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. Peak discharges for these floods are generally about 40-60 percent of the Probable Maximum Floods for the same basins. As used by the Corps of Engineers, Standard Project Floods are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

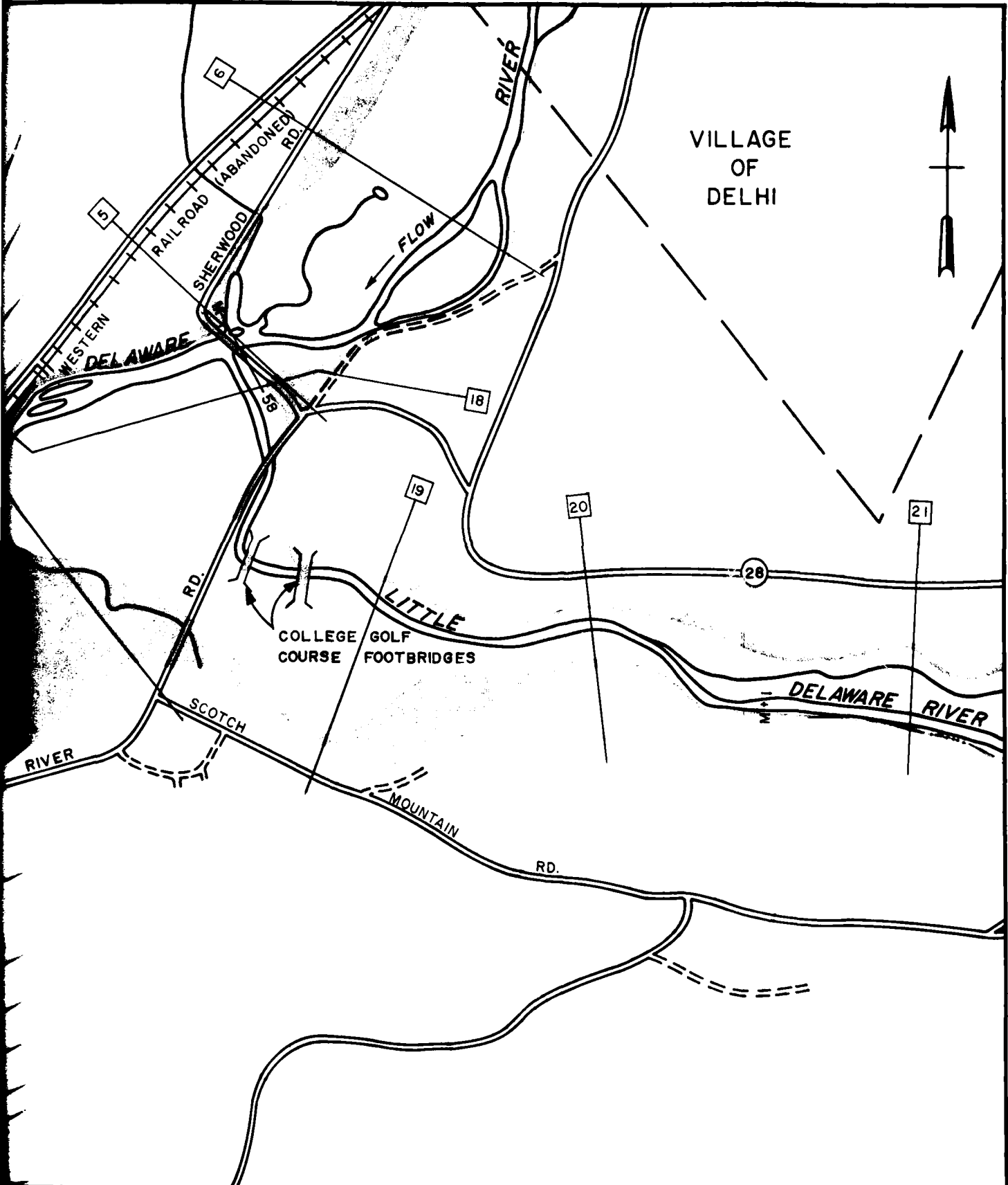
Underclearance Elevation. The elevation at the top of the opening of a culvert or other structure through which water may flow along a watercourse.







MATCH LINE PLATE 4



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NOTES

1. MAP SHEET VILLAGE NEW
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MATCH LINE PLATE 6

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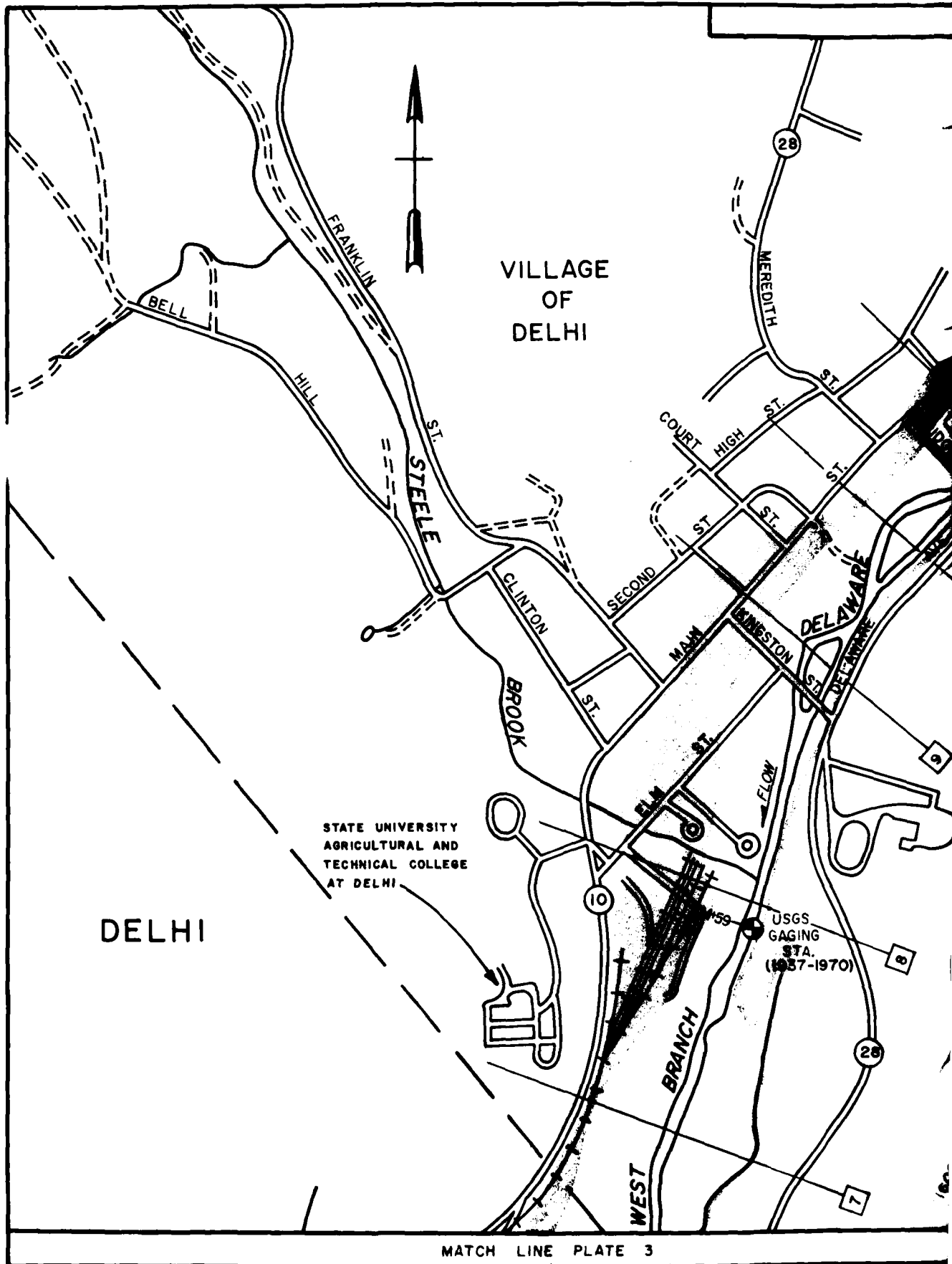
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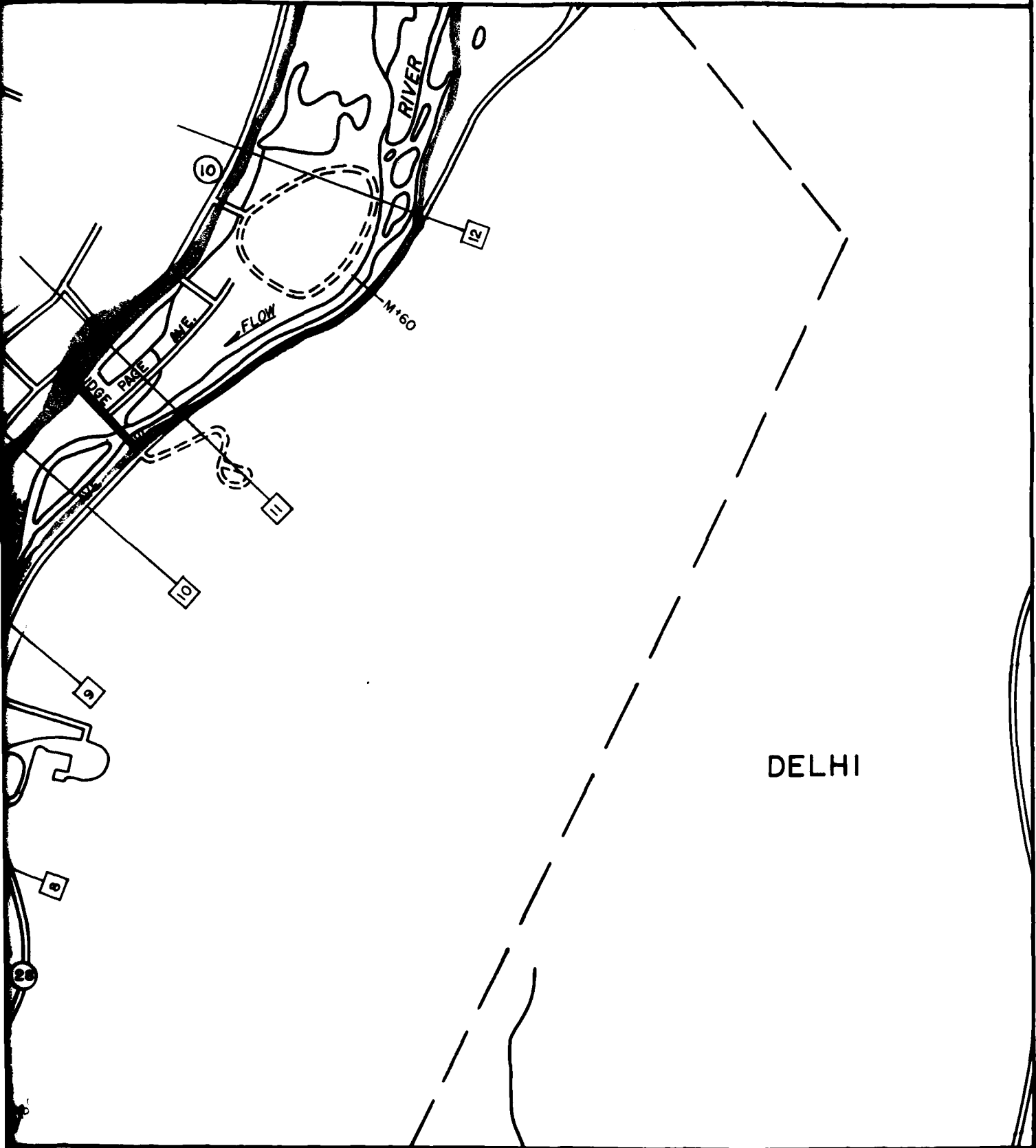
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MATCH LINE PLATE 5



MATCH LINE PLATE 6

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LEGEND

OVERFLOW LIMITS

}	INTERMEDIATE	}	STANDARD
	REGIONAL		PROJECT
	FLOOD		FLOOD

M+59 MILES ABOVE MOUTH

 CROSS SECTION

TOWNSHIP OR BORO LIMITS

GROUND ELEVATION IN FEET,
SEA LEVEL DATUM

APPROXIMATE AREA SUBJECT
TO SHEET FLOW

NOTES

1. MAP BASED ON U.S.G.S. 7.5 MIN. QUADRANGLE SHEETS: DELHI 1943, ANDES 1965 & BLOOMVILLE 1943. MINOR ADDITIONS AND ADJUSTMENTS MADE BY CORPS OF ENGINEERS.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOOD PLAIN MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. MINIMUM CONTOUR INTERVAL 100 FEET.

SCALE IN FEET

0 800 1600

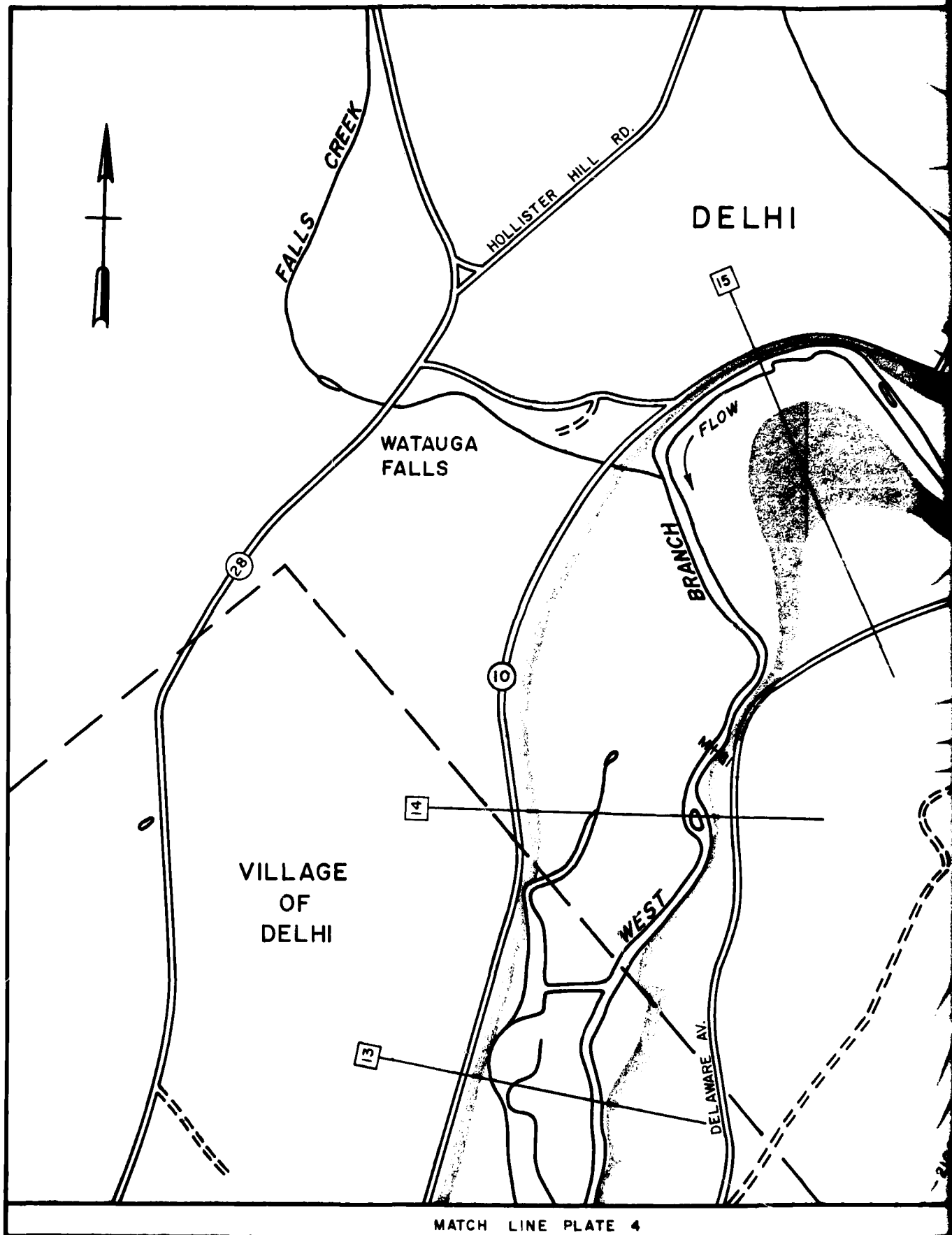


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PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

FLOOD PLAIN INFORMATION

VILLAGE AND TOWN OF DELHI
DELAWARE CO. N.Y.

FLOODED AREAS



LEGEND

OVERFLOW LIMITS

	INTERMEDIATE	} STANDARD PROJECT FLOOD
	REGIONAL	
	FLOOD	

M+62 MILES ABOVE MOUTH

 CROSS SECTION

 TOWNSHIP OR BORO LIMITS

 STATE ROUTE

GROUND ELEVATION IN FEET,
SEA LEVEL DATUM

NOTES

1. MAP BASED ON U.S.G.S. 7.5 MIN. QUADRANGLE SHEETS: DELHI 1943, ANDES 1965 & BLOOMVILLE 1943. MINOR ADDITIONS AND ADJUSTMENTS MADE BY CORPS OF ENGINEERS.
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4. MINIMUM CONTOUR INTERVAL 100 FEET.

SCALE IN FEET

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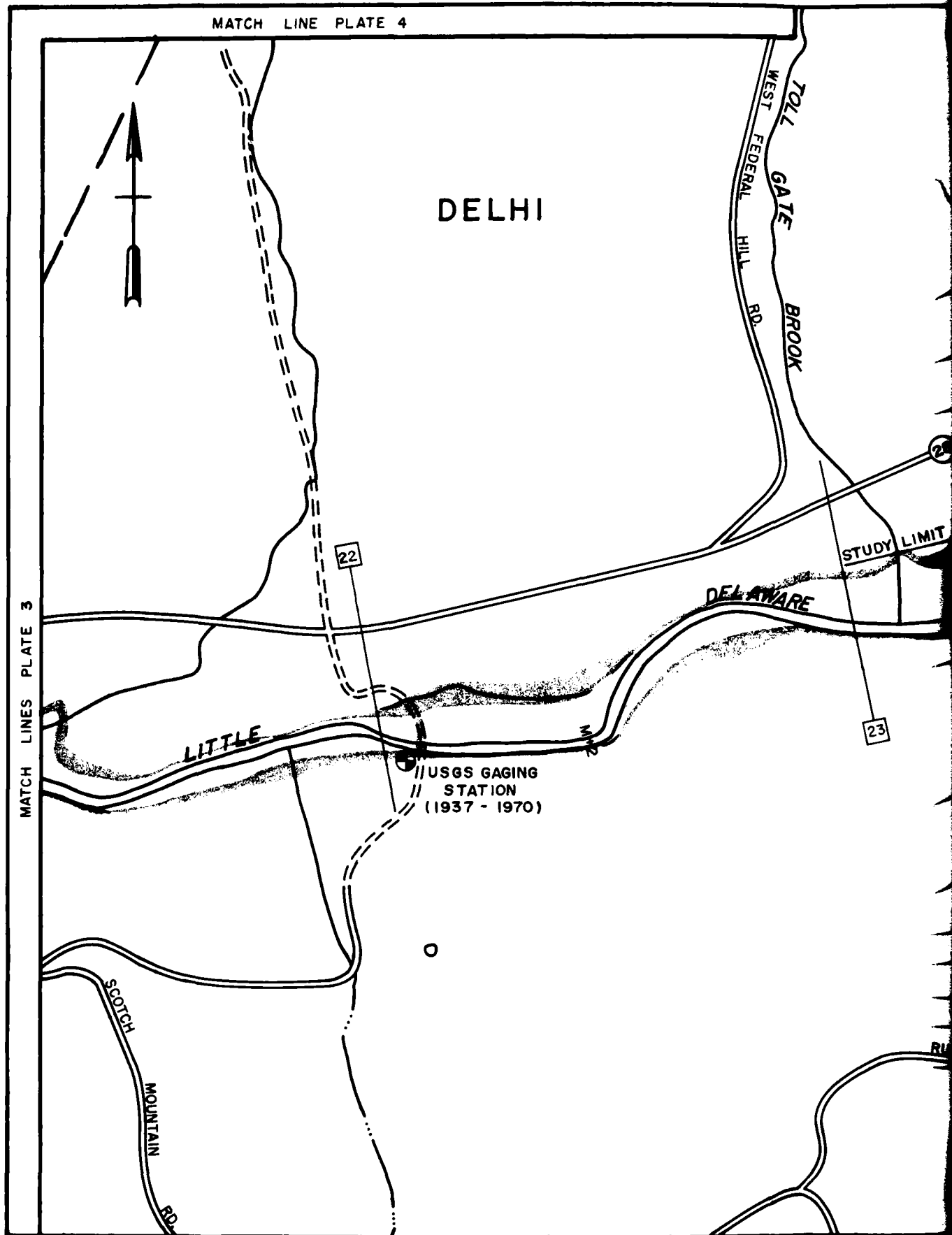


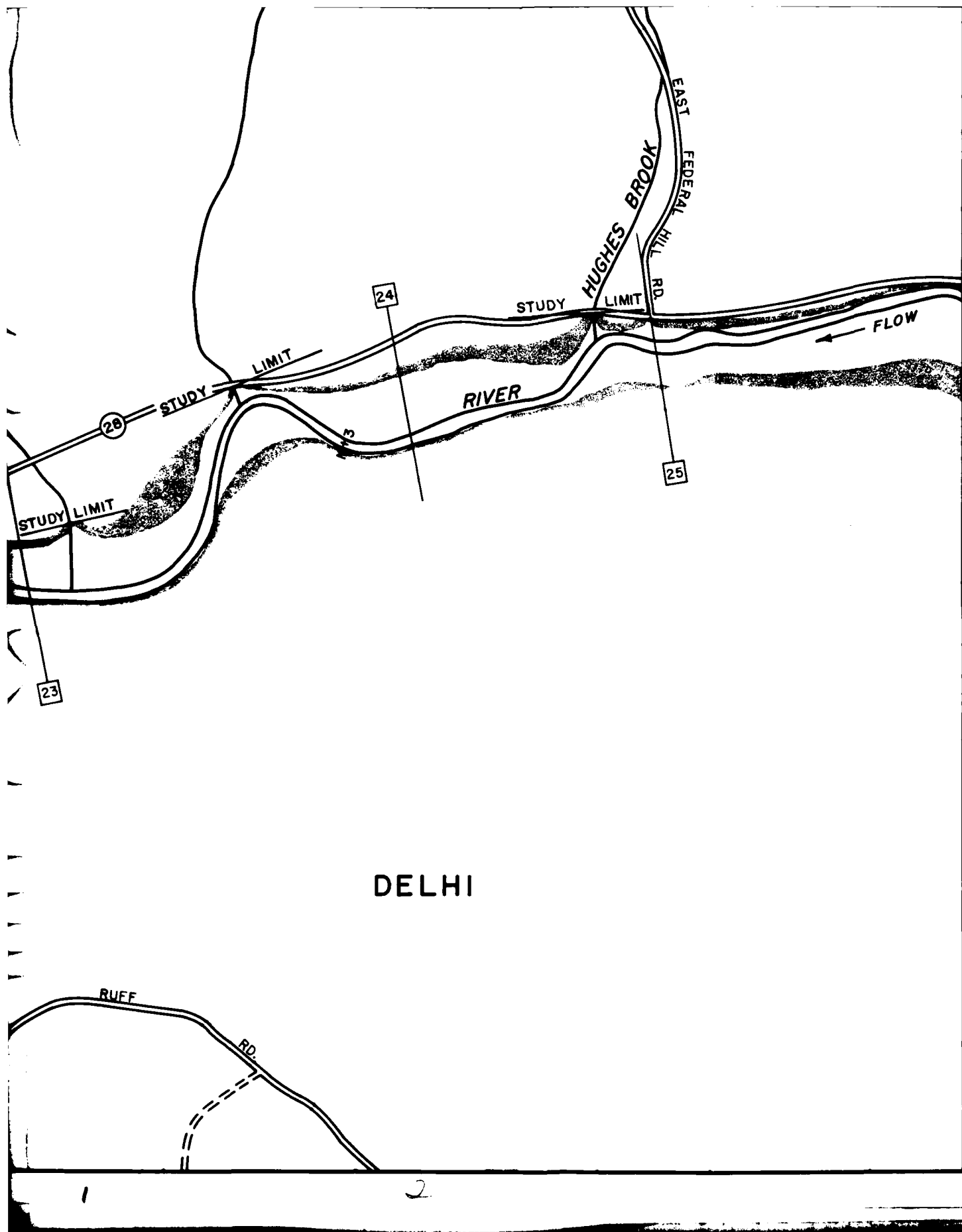
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PHILADELPHIA, PENNSYLVANIA

FLOOD PLAIN INFORMATION

VILLAGE AND TOWN OF DELHI
DELAWARE CO. N.Y.

FLOODED AREAS





MATCH LINE PLATE 7

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LEGEND

OVERFLOW LIMITS

INTERMEDIATE	} STANDARD PROJECT FLOOD
REGIONAL	
FLOOD	

M+3 MILES ABOVE MOUTH

[24] CROSS SECTION

(28) STATE ROUTE

GROUND ELEVATION IN FEET,
SEA LEVEL DATUM

NOTES

1. MAP BASED ON U.S.G.S. 7.5 MIN. QUADRANGLE SHEETS: DELHI 1943, ANDES 1965 & BLOOMVILLE 1943. MINOR ADDITIONS AND ADJUSTMENTS MADE BY CORPS OF ENGINEERS.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOOD PLAIN MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. MINIMUM CONTOUR INTERVAL 100 FEET.

SCALE IN FEET

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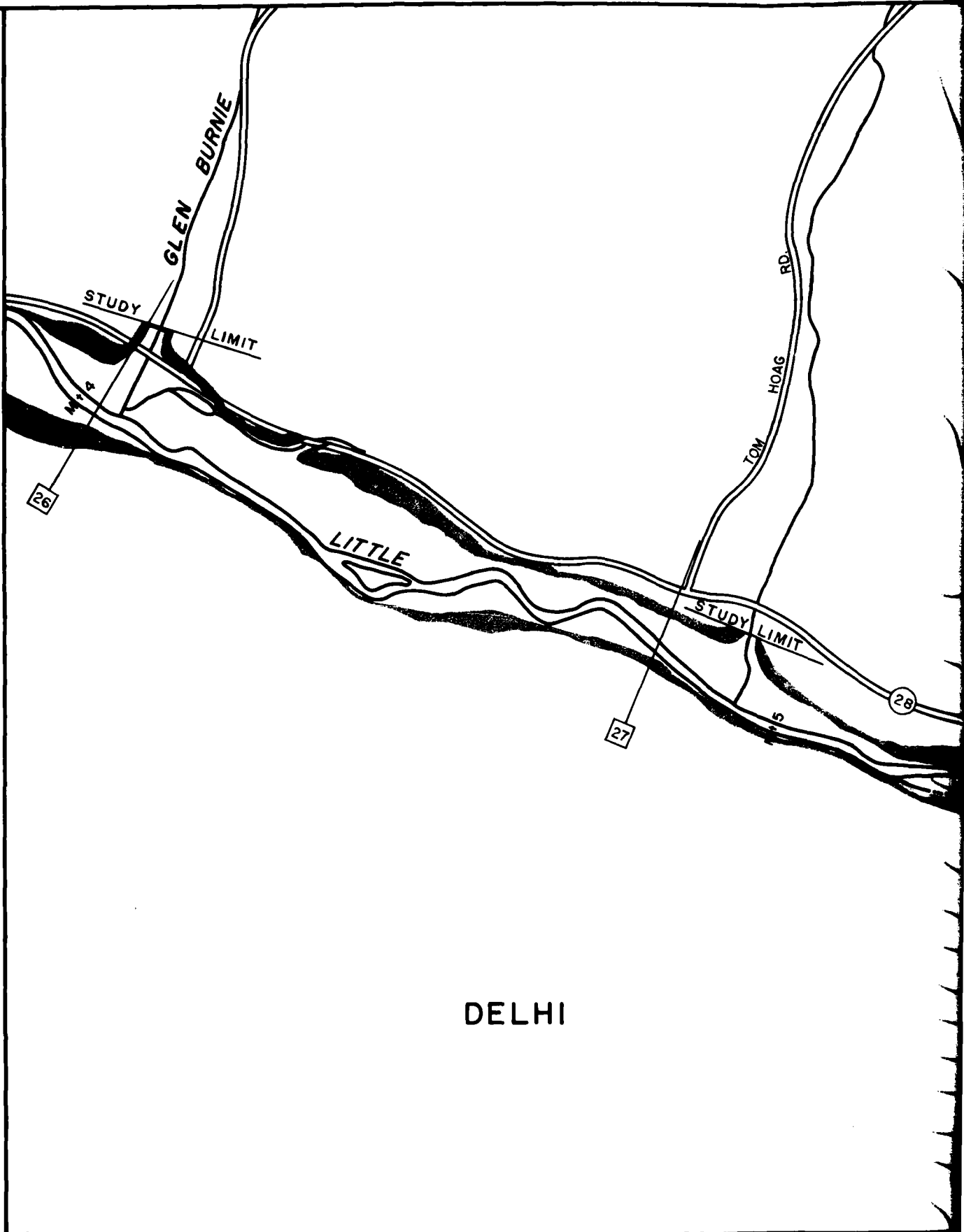


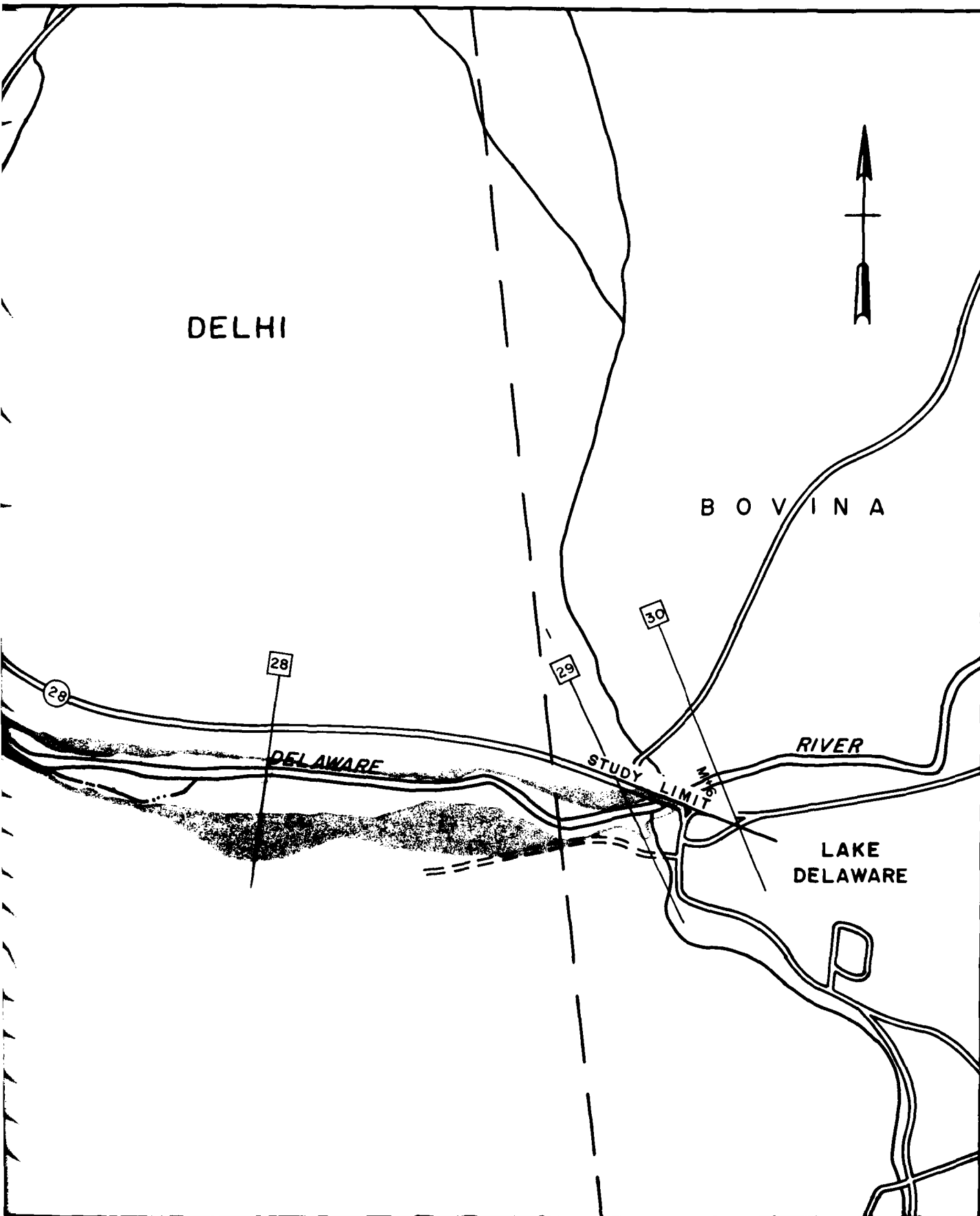
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PHILADELPHIA, PENNSYLVANIA
FLOOD PLAIN INFORMATION

VILLAGE AND TOWN OF DELHI
DELAWARE CO. N.Y.

FLOODED AREAS

MATCH LINE PLATE 6





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NOTES

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2. LIMITS OF ACTUAL L THE REPO
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VILLA

LEGEND

OVERFLOW LIMITS

INTERMEDIATE	STANDARD PROJECT FLOOD
REGIONAL	
FLOOD	

M+4 MILES ABOVE MOUTH

27 CROSS SECTION

— TOWNSHIP OR BORO LIMITS

28 STATE ROUTE

GROUND ELEVATION IN FEET,
SEA LEVEL DATUM

NOTES

1. MAP BASED ON U.S.G.S. 7.5 MIN. QUADRANGLE SHEETS: DELHI 1943, ANDES 1965 & BLOOMVILLE 1943. MINOR ADDITIONS AND ADJUSTMENTS MADE BY CORPS OF ENGINEERS.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOOD PLAIN MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. MINIMUM CONTOUR INTERVAL 100 FEET.

SCALE IN FEET

0 800 1600

DEPARTMENT OF THE ARMY

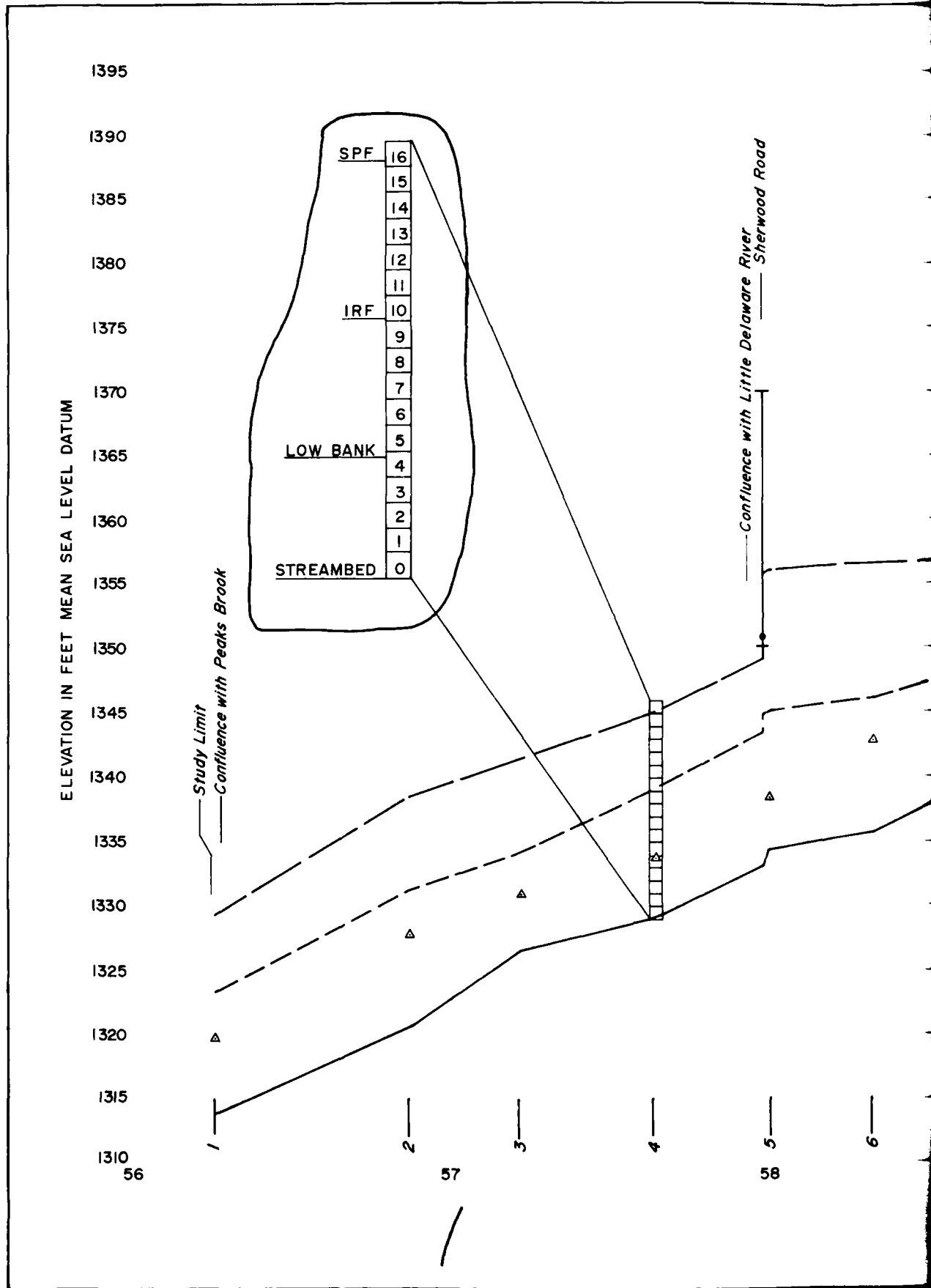
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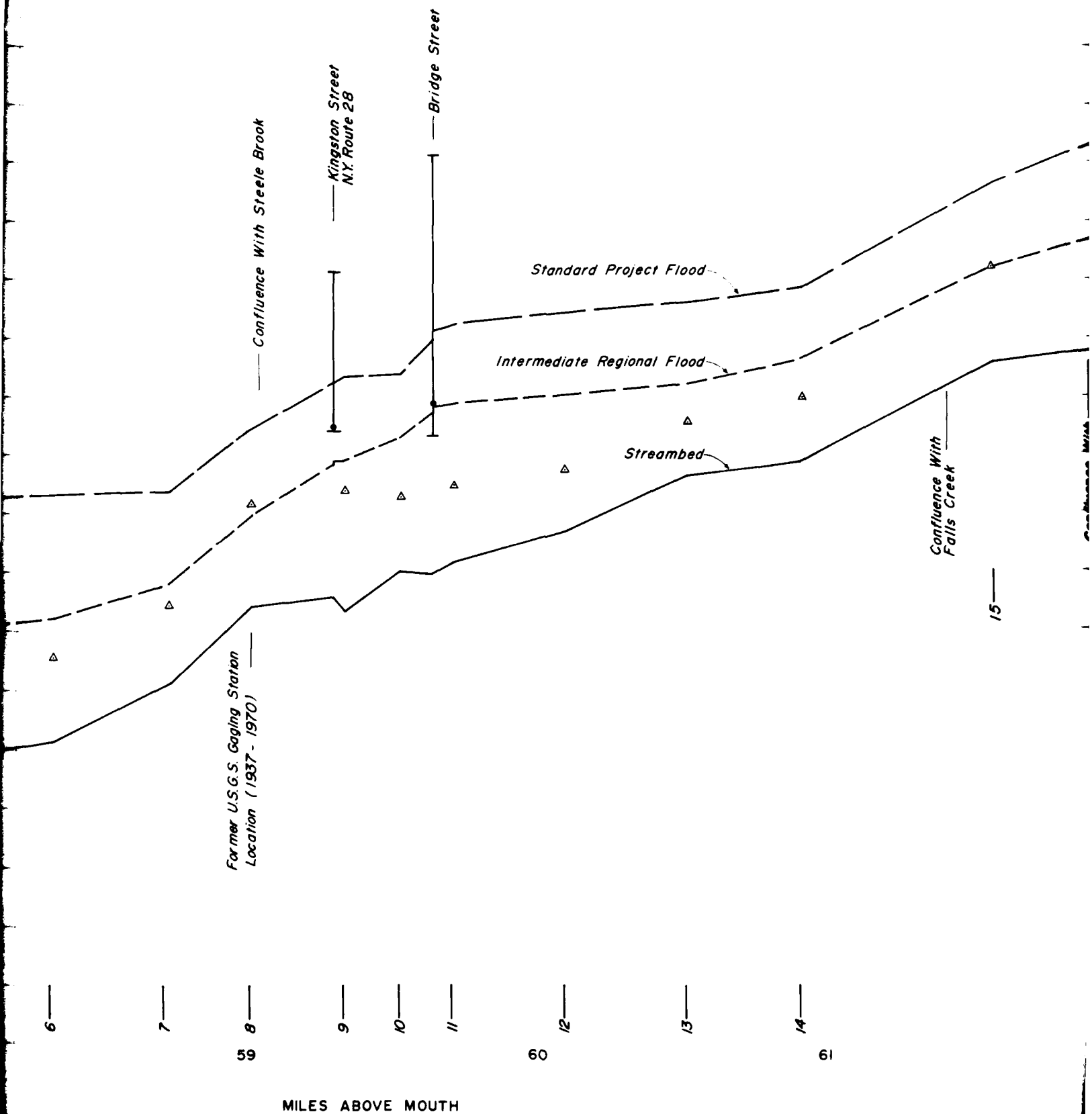
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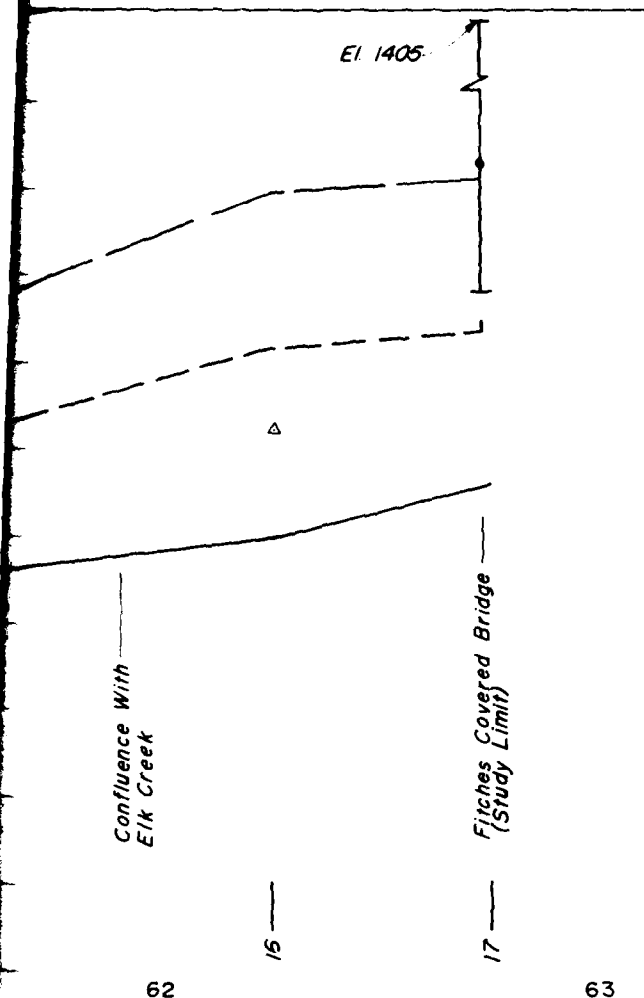
FLOOD PLAIN INFORMATION

VILLAGE AND TOWN OF DELHI
DELAWARE CO. N.Y.

FLOODED AREAS



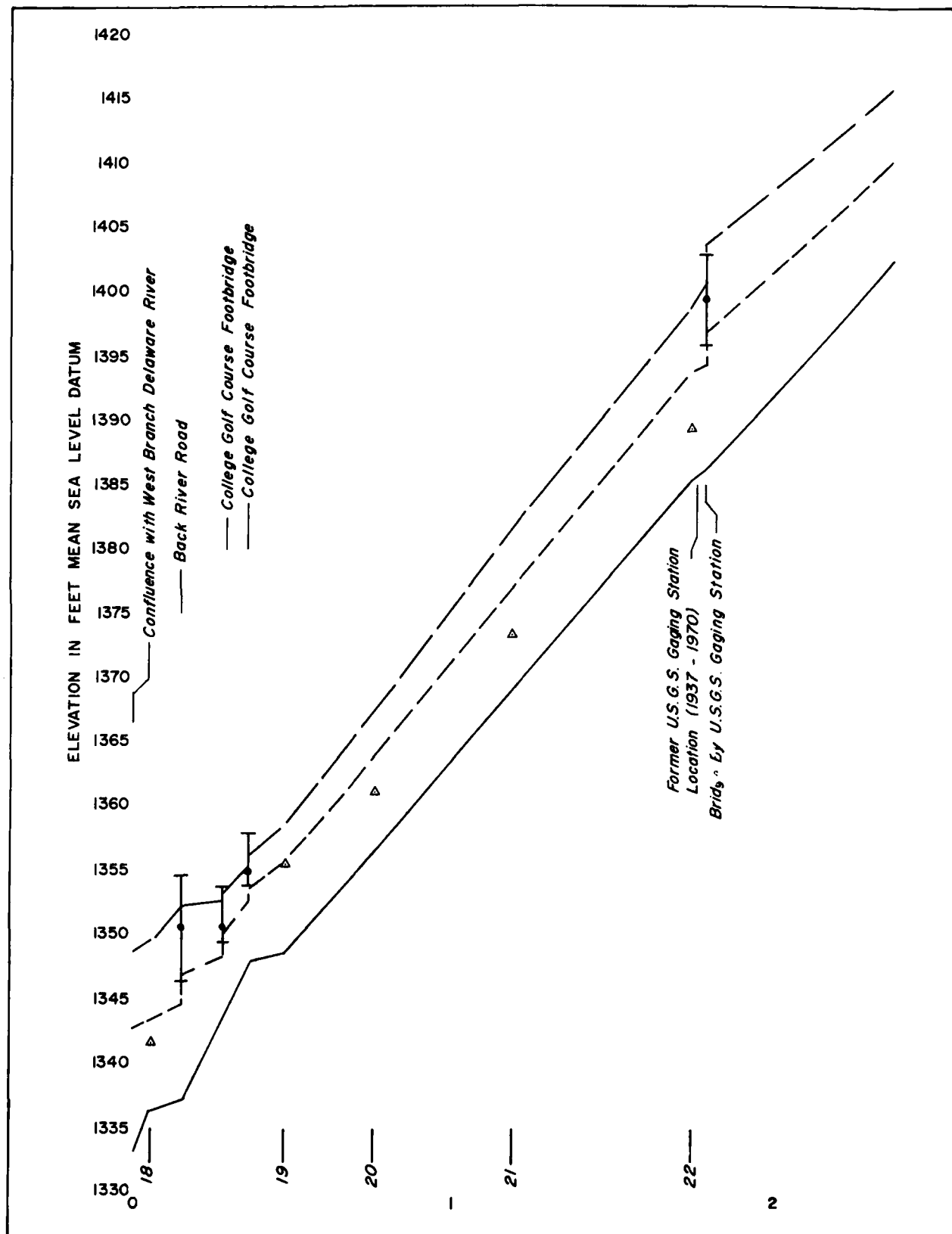




LEGEND

- Top of Bridge Railing
- Bridge Floor
- Underclearance
- △ Top of Low Bank
- 12 — Cross Section

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 FLOOD PLAIN INFORMATION
 VILLAGE AND TOWN OF DELHI
 DELAWARE COUNTY, NEW YORK
 HIGH WATER PROFILES
 WEST BRANCH DELAWARE RIVER



1480

1475

1470

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1415

1410

1405

1400

1395

Confluence With Toll Gate Brook

Confluence With Hughes Brook

Standard Project Flood

Intermediate Regional Flood

Streambed

Confluence With Glen Burnie

7	SPF
6	
5	
4	IRF
3	LOW BANK
2	
1	
0	STREAMBED

MILES ABOVE MOUTH

1535

1530

1525

1520

1515

1510

1505

1500

1495

1490

1485

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1475

1470

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2

Route 28



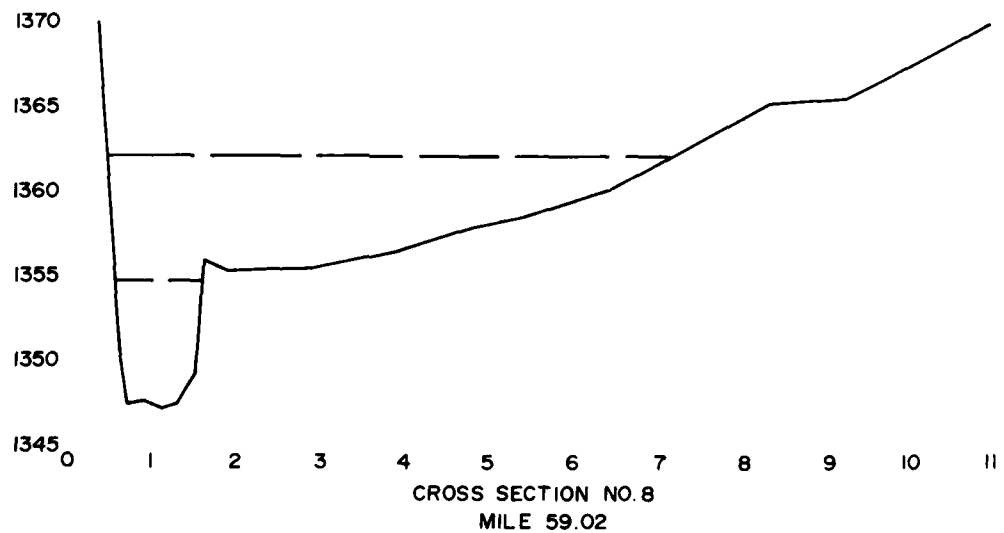
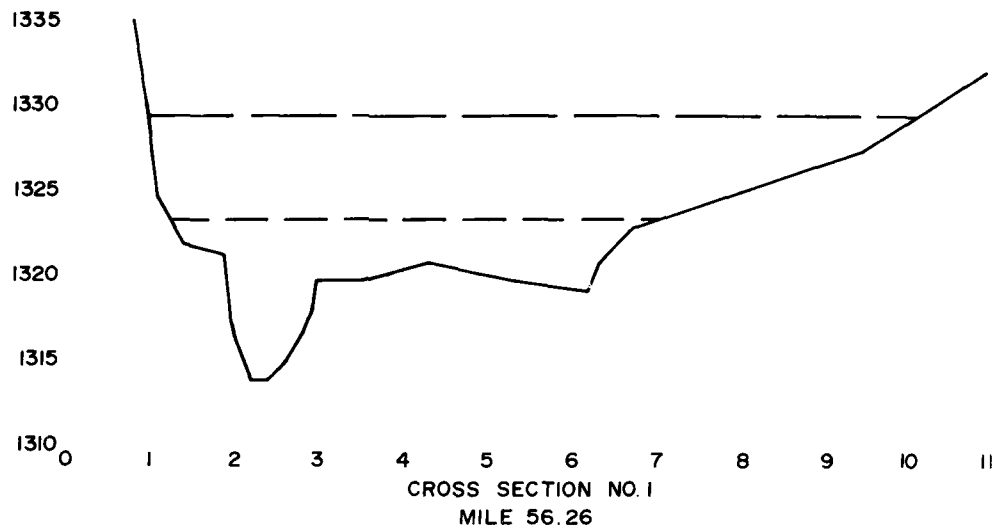
Study Limit

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30

LEGEND

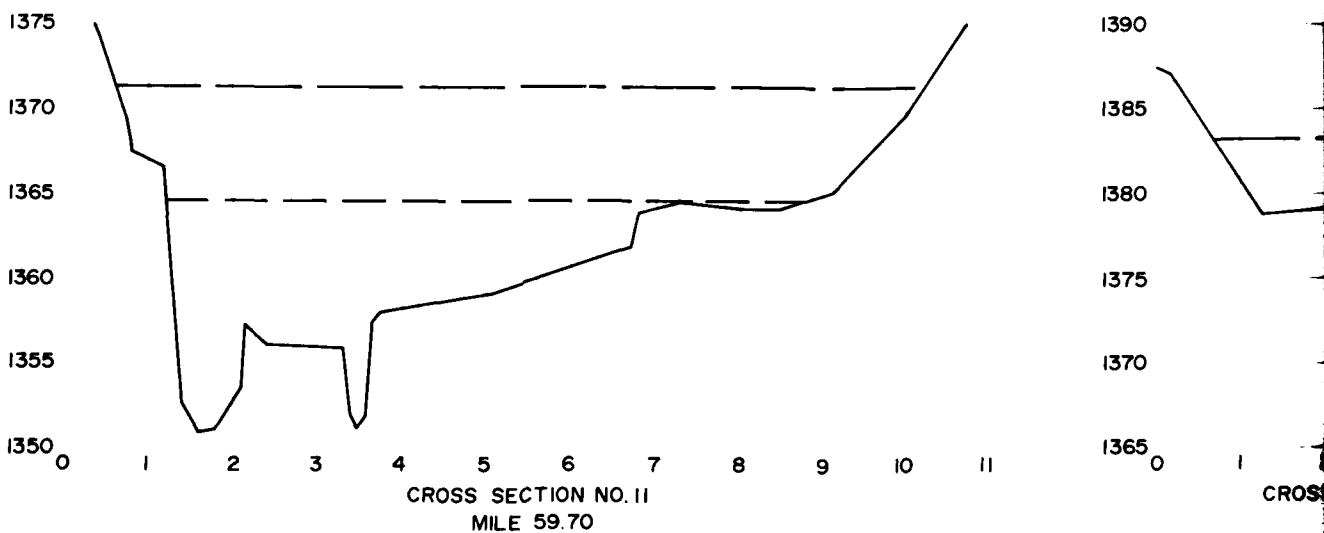
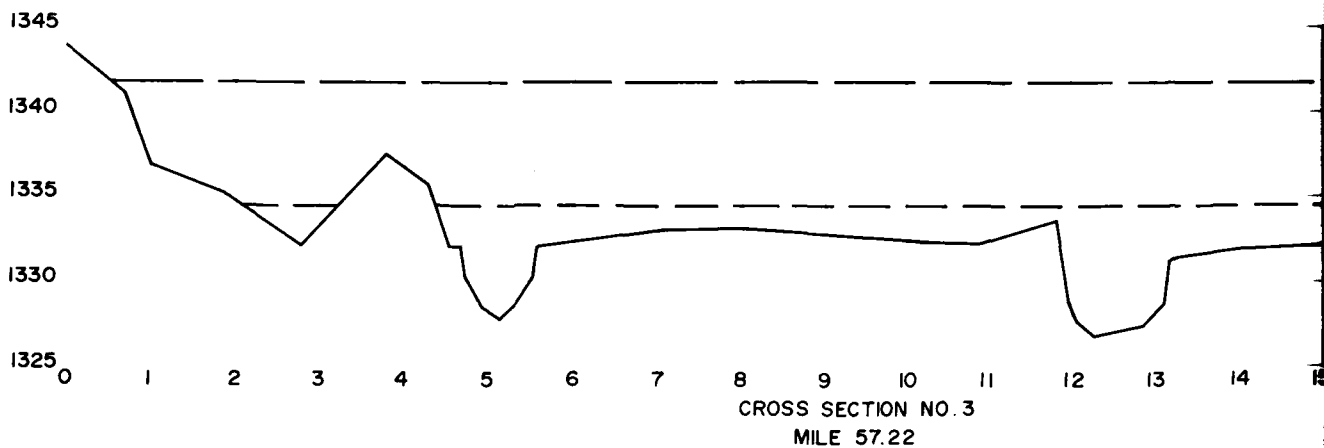
- Top of Bridge Railing
- Bridge Floor
- Underclearance
- △ Top of Low Bank
- 27 — Cross Section

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PHILADELPHIA, PENNSYLVANIA
FLOOD PLAIN INFORMATION
VILLAGE AND TOWN OF DELHI,
DELAWARE COUNTY, NEW YORK
HIGH WATER PROFILES
LITTLE DELAWARE RIVER



NOTES:

THE 20 SECTIONS ON WEST BRANCH DELAWARE RIVER
LITTLE DELAWARE RIVER NOT SHOWN IN THIS REPORT
ON FILE AT THE PHILADELPHIA DISTRICT, CORPS OF E
AND ARE AVAILABLE FOR INSPECTION UPON REQUEST.
CROSS SECTIONS TAKEN LOOKING DOWNSTREAM.

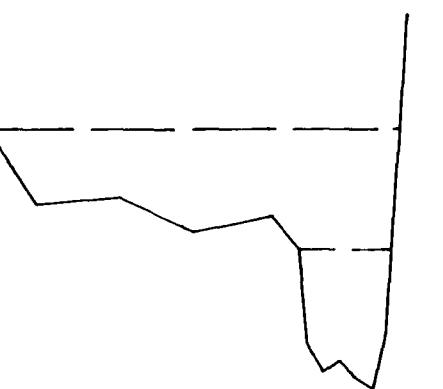
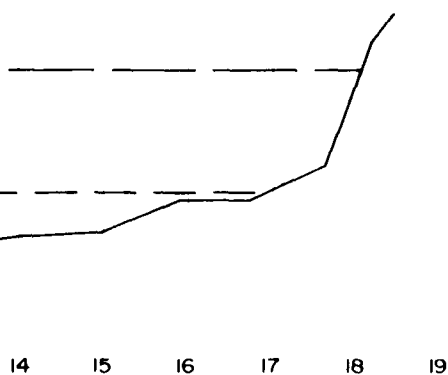


HORIZONTAL DISTANCE IN HUNDREDS OF FEET

LEGEND

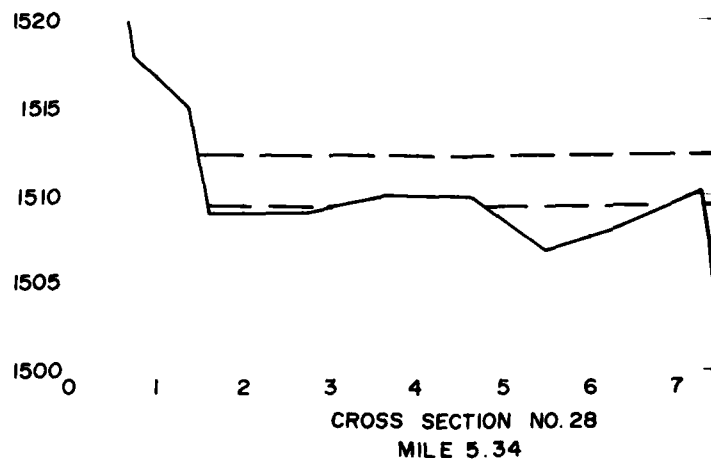
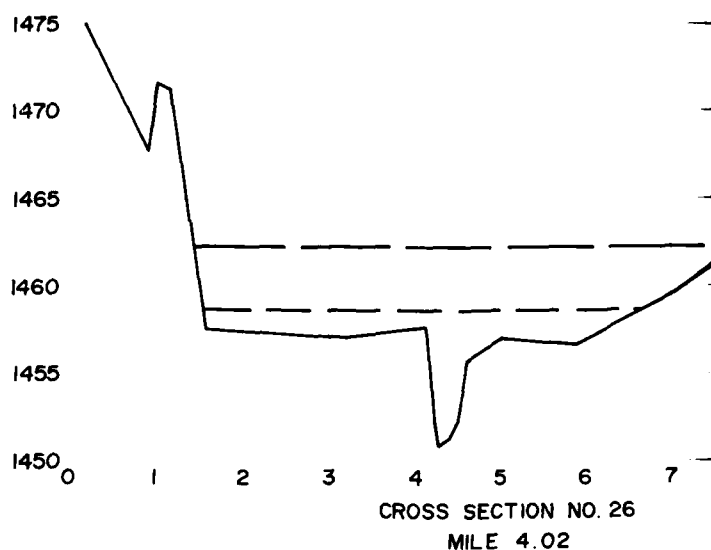
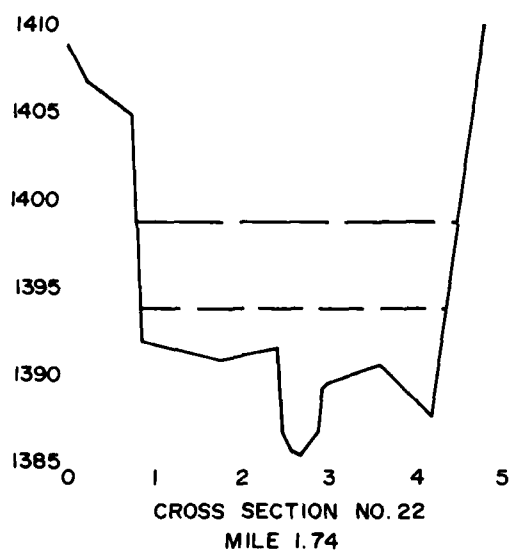
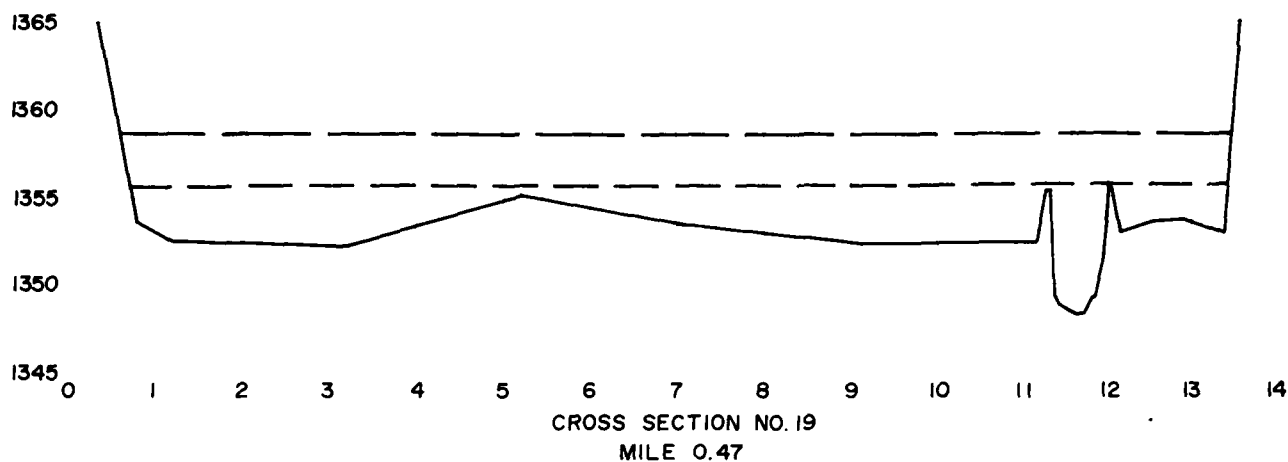
- — — STANDARD PROJECT FLOOD
- - - INTERMEDIATE REGIONAL FLOOD
- GROUND LINE

ON DELAWARE RIVER AND
IN THIS REPORT ARE
DISTRICT, CORPS OF ENGINEERS
ON UPON REQUEST.
DOWNSTREAM.

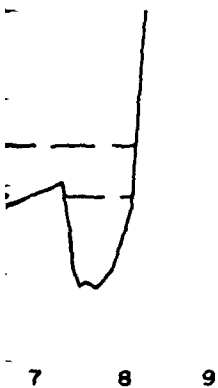
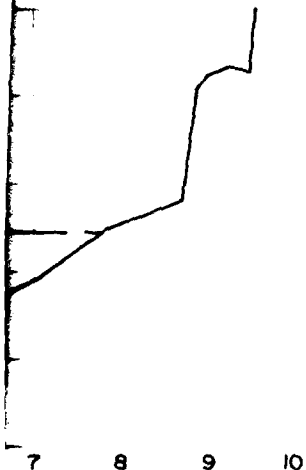
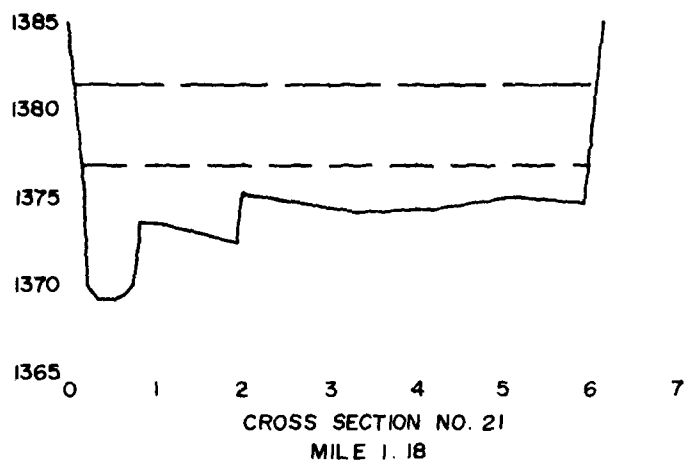


CROSS SECTION NO 15
MILE 61 58

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
FLOOD PLAIN INFORMATION
VILLAGE AND TOWN OF DELHI
DELAWARE COUNTY, NEW YORK
SELECTED CROSS SECTIONS
WEST BRANCH DELAWARE RIVER



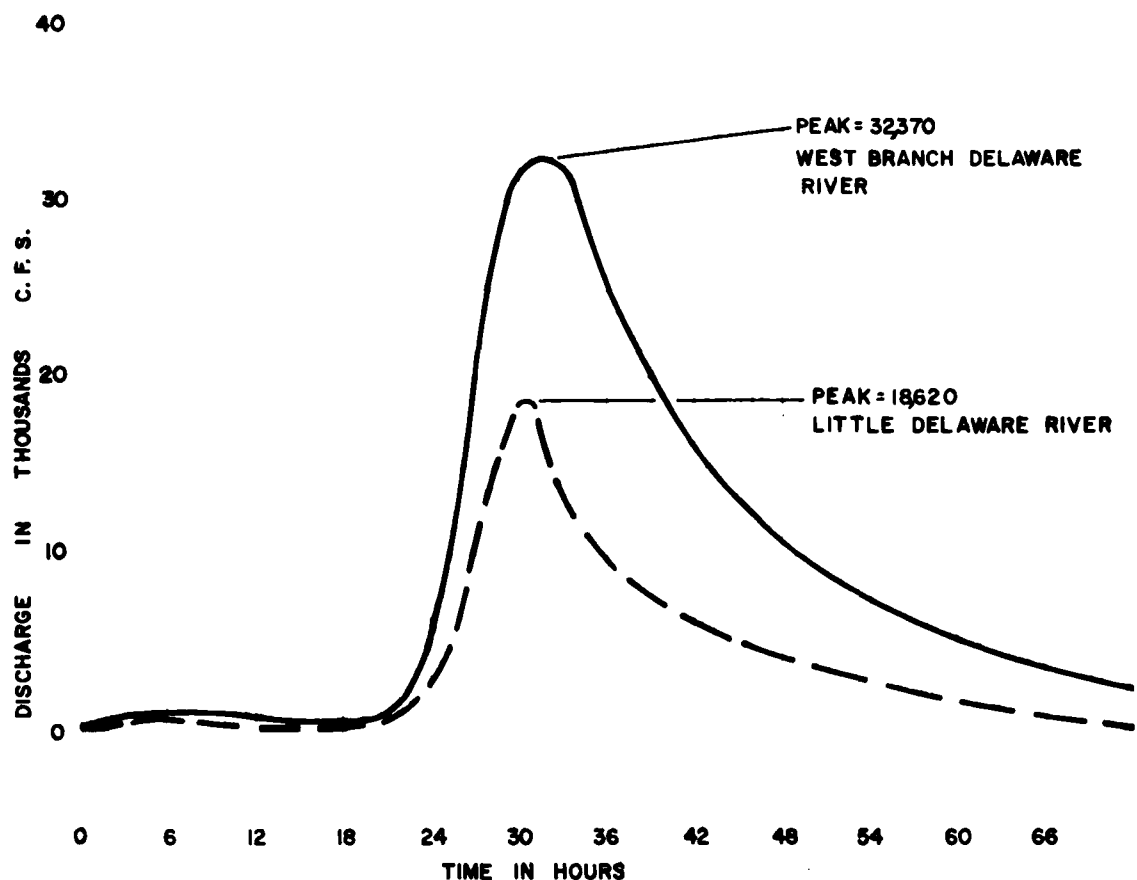
HORIZONTAL DISTANCE IN HUNDREDS OF FEET



NOTE:
FOR LEGEND SEE
PLATE 10

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
FLOOD PLAIN INFORMATION
VILLAGE AND TOWN OF DELHI
DELAWARE COUNTY, NEW YORK
SELECTED CROSS SECTIONS
LITTLE DELAWARE RIVER

FEET



NOTES:

HYDROGRAPHS ARE AT U.S. G.S.
GAGING STATION LOCATIONS

DRAINAGE AREAS	SQ MILES
WEST BRANCH DELAWARE RIVER	142.0
LITTLE DELAWARE RIVER	49.6

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
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VILLAGE AND TOWN OF DELHI
DELAWARE CO. N.Y.
STANDARD PROJECT FLOOD
HYDROGRAPHS